TEACHING THINKING SKILLS IN SCIENCE TO LEARNERS WITH SPECIAL NEEDS: AN EVALUATION STUDY

NILLY GALYAM

BSc, Teaching Certificate in Biology, MSc (*cum laude*)

(Hebrew University of Jerusalem),

Postgraduate Diploma in Education (*cum laude*) (University of Stellenbosch)

DISSERTATION

Presented for the Degree of

DOCTOR OF PHILOSOPHY

IN

SCIENCE EDUCATION

at the University of Stellenbosch

Promoter: Professor LLL Le Grange

Co-promoter: Professor CD Cilliers

August 2004

Declaration

I, the undersigned, hereby declare that the work contained in this dissertation is my own original work and that I have not previously in its entirety or in part submitted it at any university for a degree.

ABSTRACT

Effective use of thinking skills and processes affects every aspect of our lives. This study investigates the nexus between an alternative approach to science teaching with an emphasis on teaching thinking skills, and the special needs of learners in two South African classrooms.

Two cycles of intervention programmes with an emphasis on thinking skills were introduced to learners with special needs and evaluated. The aims of this study are to critically explore whether and to what extent teaching science to learners with special needs using selected Instrumental Enrichment instruments can:

- Contribute to the development of basic and science thinking skills and the transfer of these thinking skills and processes to other disciplines;
- Provide learners with special needs with an interactive science programme that is suitable for their special needs; and
- Increase student engagement in the science classroom as well as positively influence the classroom learning environment.

The study was conducted using *action research* as a method for teachers-researchers to investigate the teaching-learning situation *in situ* for the purpose of improvement and change of practice as well as for the benefit of the learners who participate in the intervention. Cross-referencing triangulation was used, in which different perspectives obtained from different sources – the teacher's, the observer's and the learners' –were combined as a way to increase the validity, credibility and dependability of the findings.

This research report offers insights into science instruction, the acquisition of science content knowledge and the improvement of thinking skills in learners with special needs. The research also deals with the transfer of thinking skills taught in one discipline into another, and raises questions about the assumptions regarding this issue in Curriculum 2005. It also throws light on the inclusive approach, underpinning the South African educational policy of inclusive education and its suitability for learners with special needs.

OPSOMMING

Die effektiewe gebruik van denkvaardighede en –prosesse het 'n invloed op elke aspek van ons lewens. Hierdie studie ondersoek die verband tussen 'n alternatiewe benadering tot wetenskaponderrig met 'n klem op die onderrig van denkvaardighede en die spesiale behoeftes van leerders in twee Suid-Afrikaanse klaskamers.

Twee siklusse van intervensieprogramme, met 'n klem op denkvaardighede, is aan leerders met spesiale behoeftes bekendgestel en geëvalueer. Die doel van die studie is om krities ondersoek in te stel of, en tot watter mate die gebruik van geselekteerde Instrumentele Verrykking in wetenskaponderrig aan leerders met spesiale behoeftes:

- 'n bydrae kan maak tot die ontwikkeling van basiese en wetenskaplike denkvaardighede en die oordrag van hierdie denkvaardighede en prosesse na ander dissiplines
- 'n interaktiewe wetenskapprogram, gepas vir hul behoeftes, kan voorsien
- leerderbetrokkenheid in die wetenskapklas kan verhoog en ook die klaskamer-leeromgewing positief te beïnvloed.

Die studie is gedoen deur *aksie-navorsing* te gebruik as 'n metode vir die onderwyser-navorsers om ondersoek in te stel na die onderrig-leer situasie *in situ* met die doel om praktyk te verbeter en te verander en om ook tot voordeel te wees van die leerders wat aan die intervensie deelneem. Kruisverwysende triangulasie is gebruik waarin verskillende perspektiewe wat verkry is uit verskillende bronne – van die onderwyser, die waarnemer en die leerders – gekombineer is as 'n manier om geldigheid, geloofwaardigheid en betroubaardheid van die bevindings te verhoog.

Die navorsingsverslag bied insig in wetenskaponderrig, die verwerwing van wetenskapinhoudkennis en die verbetering van denkvaardighede by leerders met spesiale behoeftes. Die navorsing handel ook oor oordrag van denkvaardighede wat in een dissipline onderrig is na 'n ander en bevraagteken die aannames rakende hierdie kwessie in Kurrikulum 2005. Dit belig ook die inklusiewe benadering wat onderlê word deur die Suid-Afrikaanse onderwysbeleid oor inklusiewe onderwys en die geskiktheid daarvan vir leerders met spesiale behoeftes.

Dedication

This dissertation is dedicated with love to my parents, Abraham and Tzipi Galyam,

who taught me to follow my heart and fulfil my dreams

and to Yoni Arensburg, my special friend and husband

for creating the opportunity to study and supporting me along the way.

Acknowledgements

I would like to thank all of those who encouraged, guided and helped me along the way.

I thank Professor Lesley le Grange, my promoter, who allowed me to follow my heart but opened my eyes to new ideas. For helping me to grow and develop as a researcher, as a teacher and as a person, by asking the right questions, by guiding me how to frame my work, and by supporting me throughout this doctoral study.

I thank my co-promoter, Professor C. D. Cilliers, for introducing me to some of the great theoreticians of cognitive development.

I would like to express special thanks to Professor Carl, the head of the Didactics department during my doctoral studies, who believed in me and made continuous efforts to accommodate my needs in Stellenbosch University.

I thank Ms Sandra Young and Ms Lilian Lomofsky for tutoring me in the Instrumental Enrichment course. Their input became practice in this project. I deeply thank Ms Sandra Young for our inspiring conversations about teaching and meditating in the beautiful sites of the Western Cape.

I would like to thank Mr Noel Carr for our fruitful collaboration. It was our conversations that led to better mediation and a greater understanding of the teaching-learning situation.

I sincerely appreciate the useful help of Ms Estelle Muller and Mr Leonard Adams from the University media centre, who made the video camera as well as the rest of the media centre facilities available to me whenever I needed them.

I would like to thank Ms Sally le Roux for the kind help she always offered in her friendly way.

I thank Professor Rautenbach for sharing with me his experience with Feuerstein's Instrumental Enrichment and helping me focus my project.

I thank Dr Edwin Hees for assisting with the language editing of this dissertation so willingly.

I thank the director of Pro-Ed school, Dr Anita Worrall, who allowed me to conduct this research in her school, and to my very special learners, who participated in this project.

Lastly, I would like to thank my friends in Stellenbosch, Nivi, Sharath and Vasu, Florian and Rolin, Sven and Seanagh, for their interest in this study and for the constant support they provided, and I thank the M&B for their warm welcome and coffee.

Table of Content

List of Tables and Appendices

Tables

Appendices

List of Abbreviations

AAAS	American Association for Advancement of Science
ACT	American College Testing
ADD	Attention Deficit Disorder
ADHD	Attention Deficit Hyperactive Disorder
AR	Action Research
BCTP	Biology Critical Thinking Project
CAT	California Achievement Test
CoRT	Cognitive Research Trust Thinking Programme Edward de Bono
COGNET	Cognitive Enrichment Advantage (CEA)
CTA	Watson-Glaser Critical Thinking Appraisal
EAR	Evaluation Action Research
GCSE	General Certificate of Secondary Education
GET	General Education and Training
IDEA	Individuals with Disabilities Educational Act
IE	Instrumental Enrichment
IEP	Individual Education Plan
ILEA	Inner London Education Authority
INDS	Integrated National Disability Strategy [White Paper on]
LD	Learning Disabilities
MLE	Mediated Learning Experience
NSLAS	Natural Sciences Learning Area Statement
OBE	Outcomes-based Education
OOD	Organisation of Dots
PAR	Participatory Action Research
RNCS	Revised National Curriculum Statement (2002)
SAT	Scholastic Aptitude Test
SOR	Stimulus - Organism - Response
SR	Stimuli - Response
TST	Teacher Support Team
ZPD	Zone of Proximal Development

Chapter One

Introduction

1.1 Introduction

Living in an era of change and development, we are constantly challenged by new scientific information and technological developments in a complex social environment. Part of being able to adapt to this rapidly changing environment depends to a large extent on the ability to think adequately and reach decisions based on reasoning, analysis and synthesis of information. Effective use of thinking skills and processes affects every aspect of our lives in social, professional or day-to-day contexts. Therefore, one of the main goals of educational systems nowadays is emphasising the development and improvement of, and instruction in, thinking skills and processes throughout the curriculum.

Because of my belief in equal opportunities and democracy, I felt that it was my responsibility as science educator to help learners develop and fulfil their potential. Specific turning points in my own history led me to believe that there should be an emphasis on thinking skills in science education programmes. I realised that cognitive ability is a key to success in life and may affect the learners' future socio-economic status, and that decision-making based on rational and logical thinking determines the future of these learners directly, and the future of our society as a whole. I wanted to be actively involved in the personal change and growth of learners as they develop thinking skills in general and in science contexts in particular, and made this my first objective as a science educator. I decided to strive towards providing learners with tools and strategies for better learning, and to help them to develop cognitively. This is the ethos which guided this study.

Children's cognitive development depends on two main domains: biological and social [(Gindis 1995) p. 78, (Feuerstein *et al.* 1981) p. 272]. Pre-determined, genetic factors and some congenital factors affect the potential of cognitive development.

However, children do not develop in isolation but in their surroundings and in specific social contexts. The interaction with their close social environment affects their cognitive and psychological development as well.

Many learners are exposed to an environment that helps them develop specific cognitive skills, which in turn allows them to become independent learners. These learners continue to learn throughout their lives using direct exposure to stimuli as opportunities for learning. This is done by mechanisms of assimilation and accommodation which Piaget described and which have become known as the 'constructivism theory' [(Feuerstein and Feuerstein 1991) p. 9].

On the other hand, there are learners who develop differently. The etiology of learners with special needs suggests that either biological or social factors or the combination of the two can lead to difficulties in learning. Some learners may struggle to learn on their own and might not be able to benefit from direct exposure to stimuli, and sometimes might even display cognitive dysfunctions. For many years learning difficulties or disabilities were considered as a static state, with no possibilities of change or improvement with time or effort invested. It was accepted that unless cognitive ability developed properly at a young age, there was little one could do in order to change the delayed development, or lack, of cognitive functions.

In the last three decades more and more evidence has accumulated suggesting that thinking skills and processes and cognitive functions can be mediated and developed by learners with a wide range of abilities [(Costa 1991; de Bono 1993; Feuerstein *et al.* 1981; Frankenstein 1979; Gindis 1995; Kozulin and Presseisen 1995)].

Vygotsky, Feuerstein and others theorised on the etiology of learners with special needs. Intervention programmes to develop thinking skills and processes started to emerge. Increasingly more educators believed that something could be done to improve cognitive functions and that thinking can be taught and developed intentionally. Studies that evaluated these intervention programmes were conducted, providing evidence for possible changes in learners' ability to solve problems and apply thinking skills. What characterised most of these intervention programmes was the need for special effort, high level of motivation and focused intention on the educator's part so as to help learners develop thinking skills and to fulfil their potential.

For many years science teaching has been dominated by the transmission of content knowledge to learners [(Wellington 1989) p. 8]. School science education programmes were designed mainly to meet the needs of higher education and therefore became the route for training scientists. Over the years more and more content knowledge was included in school science syllabuses. This trend became known as the content-led approach in science education. However the content-led teaching style was found to be suitable mainly for learners with above average abilities, but was shown to be not as suitable for learners with average or below average abilities. This, together with other reasons, influenced a change in science education, which was characterised by placing greater emphasis on teaching thinking skills and processes; this became known as the 'process-led' approach. Some argue that skills and processes, especially if they can be transferred to other learning areas, are more relevant to learners than transmitting factual content to them. Others argue that skills and processes are more accessible to a much wider range of ability than traditional approaches to science education (the transmission of facts) would seem to allow [(Screen 1986)]. As Robinson (1987: p. 13) notes:

> While the importance of cognitive development has become widespread, students' performance on measures of higher order thinking ability has displayed a critical need for students to develop the skills and attitudes of effective thinking [in (Cotton 2000) p. 2].

My aim in this research is to reflectively teach specific skills and processes that are known to be representative of problem-solving activity in science [Gange 1970 in (Shaw 1983)] to learners with special needs, using a specific intervention programme known as Instrumental Enrichment (Feuerstein 1980). Learning the skills explicitly in science programmes may help learners to transfer them to other disciplines as well. These skills and processes can serve – in Millar's (1989) terms – as 'general approaches which we all use all the time in making sense of the world'.

In particular, the aim of this study is to critically explore whether and to what extent teaching science to learners with special needs using selected Instrumental Enrichment instruments can:

- Contribute to the development of basic and science thinking skills and transfer of the thinking skills and processes to other disciplines;

- Provide learners with special needs with an interactive science programme that is suitable for their special needs; and
- Increase student engagement in the science classroom as well as positively influence the classroom learning environment.

In my study I intend to document a praxiological account of how the nexus between an alternative approach to science teaching and the special needs of learners is played out in two South African classrooms. My study is pertinent to South Africa because recent policies on the curriculum, inclusive education and disability mandate that science processes/skills be taught to all school learners.

The aim of this chapter is to outline the problems and motivation for conducting this study, and to provide the background (including autobiographical elements) which influenced my choice for conducting this study in the way I did.

1.2 Turning Points and Personal History

My personal life history played a significant part in influencing some of the major decisions I made in my professional life. A few turning points in my life had a significant influence on this study, which led me to investigate specific questions related to science and special education. Ballenger (1992, p. 201, in Le Grange, p. 3) claims that:

> An important part of the research project is examining where a particular research question comes from in one's own life - why it seems important to the teacher-researcher. In many cases, this is a matter of investigating one's own socialisation, a kind of a self-reflection that becomes an important part of the investigation.

I shall now elaborate on these turning points which influenced the research questions I formulated and my choice to conduct this research.

I was taught by my parents to appreciate nature and to learn about it, and was exposed to the outdoors since an early age. I was encouraged to join the Israeli Natural Conservation afternoon class in Jerusalem and participated regularly in their activities, which involved learning about the land and nature, Israeli society, the people and their culture. This continued to form and shape my appreciation of nature as well as my appreciation of our diverse society in terms of socio-economic background and different origins.

I studied at the Hebrew University High School, which selects its students according to their scholastic achievements and according to psychometric tests. The school also offered a unique intervention programme for learners from disadvantage backgrounds, who were educated according to a programme for special education initiated by Prof. Carl Frankenstein from the Hebrew University. Most of the learners who lived in underprivileged environments were usually educated in high schools that considered them to be average or below average learners. The school programmes were based on low expectations of the learners and trained them to become secretaries, motor-mechanics, service providers, etc. Most of them did not get the opportunity to obtain a full matriculation, which in turn influenced their career choices, their course of life, and probably determined their socio-economic status and that of their children. On the other hand, the underprivileged learners in Frankenstein's programme at the Hebrew University High School were evaluated and recognised as having the potential to achieve scholastically better than they did before entering the programme. Due to different circumstances, as Frankenstein tried to explain, these learners who later entered his programme, developed differently and did not fulfil their potential (Frankenstein 1979). Frankenstein's programme was very effective and the learners graduated at the Hebrew University High School with a full matriculation, many finding their way into higher education.

Though I did not fully understand what the programme was about (it was only later that I found out), this programme left an indelible impression on me. I realised that the gap between failure and average ability can be closed, and the consequence of this can be success and potential fulfilment. My very first understanding of potential fulfilment, intelligence and the possibilities of change remained imprinted on my mind ever since.

I was drafted into the army after finishing my high school education and was appointed, at my request, as a guide in the Golan Heights field school. I educated civilians, mainly high school learners from all over Israel. When I could choose, I preferred guiding the classes, which we refer to in Israel as the 'advancing' classes and which were usually classes of underprivileged learners. I enjoyed the challenge of 'convincing' them that the region is not, as they used to claim, only 'sand and rocks'. Part of my practice was to provide content-knowledge regarding the region's geography, history, cultural and natural aspects, as well as political issues. I remember feeling that I had influenced the learners' ideas regarding different issues, increased their awareness of nature and its value, and helped them shape their personality and beliefs. I found that increasing awareness of political issues by providing different sides to our country's history and of disputes over our land intrigued the learners and made them re-examine their beliefs or thought patterns. I also remember thinking that three to four days of an educational outing was too short a period to influence them significantly, and that teaching learners for a longer period might be very interesting to consider as a profession (although, unfortunately, I could not find many teachers or other adults that shared these feelings with me).

Later, I graduated from the Hebrew University in Jerusalem with a bachelor's degree in Biology and a master's degree in Biochemistry. I also completed a Teaching Diploma in Biology for high school during my studies at the university. One of the courses in the Teaching Diploma was a course dealing with Frankenstein's theory, which explained the etiology of learners manifesting difficulties in learning due to disadvantaged conditions. According to Frankenstein, underprivileged learners could fulfil their potential if they were to become involved in an appropriate intervention programme run by trained teachers. He claimed that the learners' lack of cognitive functions is a reversible state [(Frankenstein 1979) p. 30]. Since I continued my studies at the Jerusalem Hebrew University, I did not get a chance to implement his theory or practice immediately.

I was tutoring two courses for first- and second-year students doing a bachelor's degree in Biology while I was doing my masters' degree at the university. In these courses I further developed my skills to mediate concepts in biology by simplifying and associating them to other familiar subject matter. Even though I enjoyed teaching university students and transmitting knowledge, I must acknowledge the experience was not as fulfilling as that of an educator who can influence and help learners in some ways to shape their character as well as their courses of study at an earlier age. It was during my master's degree studies that I decided to become a full-time high school teacher and to experience the work that a school educator does.

1.3 The Problems: Finding Meaning and Lack of Basic Thinking Skills

I started my teaching career as a Biology and Chemistry teacher for Grade 10 learners in a regular neighbourhood high school in Jerusalem. Teaching only 8 hours a week at the beginning of the year left me with plenty of time to prepare biology and chemistry materials in a simple and suitable way to meet the learners' ability. The school head of Biology instruction chose the Biology content knowledge (*'cell biology'*) for the Biology team, as was the case for the Chemistry content knowledge (*'the periodic table'*).

I was always fascinated by molecular cell biology and was sure I would be able to share this passion with the learners. Surprisingly, many of the learners complained that they could not relate to this subject matter at all. They could not understand the *meaning* of it in a manner that would enable them to relate to the subject matter. I, on the other hand, was not accustomed to providing the *'meaning'* behind the subject matter. I was expected to teach this content knowledge, since it formed part of the prescribed syllabus, and I never questioned why I should do so. When I tried to link the subject matter to their lives, it was difficult for me to explain why the concepts and knowledge of *'cell biology'* were important to Grade 10 learners, who were in their last year of studying Biology at high school.

In addition, many learners displayed a lack of basic skills and processes, some of which related to science, while others were basic skills of a generic kind, those necessary for almost any scholastic task or problem-solving activity. For example, many of the learners could not compare plant cells and animal cells systematically. Many learners could not understand how cells fit into the body system or into plants, although we worked through the hierarchy of the human body and plants from systems to cells. Apart from difficulties in making proper comparisons and differentiating between levels of complexity, they could not summarise what was said during the lesson in the class and many could not take down notes in their books. Many of the learners were not able to analyse a passage in the textbook on their own and to apply knowledge to a new task. I felt that most of the learners were able only to recall content knowledge, but if they were asked to analyse or solve problems based on this knowledge, they could not succeed. Many of the tests, which I thought were fair tests on the subject matter I had covered, learners found too difficult to solve.

I tried to figure out how I could help the learners to become more competent in this regard. Since I did not have the tools to help them overcome their lack of basic thinking skills and processes, I consulted with some of my fellow staff members in an effort to gain a better understanding of to how to approach these problems. Some of my colleagues said that what I experienced was the normal level of performance in this school and I must be satisfied with the recall of knowledge displayed by the learners. The tests set by other staff members, which I had perused, revealed that the questions posed mostly required of learners to recall content knowledge. I could not find any satisfactory approach used or recommended by the staff members in order to change the level of performance, which I perceived to be below the standard for high school learners.

As the year continued I substituted for two teachers who took leave for a few months. I taught over 20 hours a week, which included working with learners in Grades 10, 11 and 12. I started teaching Ecology to Grades 11 and 12. The learners in the Ecology class, who had become accustomed to the Ecology teacher for whom I substituted, 'demanded' that I should dictate or write on the black board a summary of everything we discussed in each lesson. I refused to do this and decided to consult with the Ecology teacher, who confirmed that dictation was part of the routine. Because I replaced the teacher for a few months, I thought it wise not change the approach that learners were used to in the middle of the year, and therefore continued with an approach that encouraged rote learning. Another difficulty arose when I had to check the theoretical part of an Ecological Project that serves as part of the matriculation final mark. I saw that some learners copied parts of the textbook into their theoretical chapter of the project assignment, with no attempt to summarise or combine more than one source of information. They produced no evidence of any level of analysis or synthesis. Sharing my concern with the Ecology teacher elicited the following response from her: 'Don't try and change the unchangeable. Be happy that there is something in the theoretical part at all.'

What I have described above reflects learners' inability to gather information from a textbook, to differentiate between relevant and irrelevant knowledge, and to analyse how the information fits into their project. They could not process information in the text or the knowledge acquired by choosing what information or cues to use, and to communicate this meaningfully in their own words. These are all skills that are not necessarily related to science, but rather affect a learner's ability to understand and process texts in any subject matter. These skills are assumed to have been mastered by the learners in Grades 10, 11 and 12. Unfortunately, the expectations of the learners were very low, so much so that staff members did not make any attempt to teach the thinking skills and processes explicitly, nor to provide the stimuli that would enable better performance from the learners. Since these skills were not manifested at the basic level, how can one expect them to be manifested at more complex levels?

However, as much as I was frustrated by the performance of average learners in a normal Jerusalem high school, and as much as I wanted to change the situation, I had no strategies and no tools to do this. Moreover, I was expected by my colleagues and the head of Biology instruction to lower my own expectations of the learners, and to adjust my teaching and tests accordingly to accommodate this (mediocre) teaching style. I was taught and trained to transfer content knowledge in science, and simplify even the most complex concepts in biology to learners with a wide range of abilities. But I was never trained properly to teach basic skills and in reflective moments I started thinking about how to teach basic comparison, what classifying entails, and how to provide the *meaning* behind skills and content knowledge. I wanted to help the learners become independent, but I did not know how.

My first year as a science teacher in a regular high school had a significant impact on me in the sense that I was not willing to accept the way in which learners' performance was curtailed to a certain level of competence in high school. I decided that I would not become part of a system that did not strive to change this reality for the learners and I was not willing to waste my time as a teacher by dictating fragments of content knowledge. I have always thought that textbooks and notes are sources for the storage of content knowledge and should be made available for learners to use, and that my expertise as a teacher was not solely to provide the information, but rather to explain and mediate concepts and principles. I was keen to mediate principles and concepts in science, but was even more interested in teaching thinking skills and processes. This disposition stems from my understanding that, without the skills of summarising, comparing, classifying, listening critically, choosing relevant cues of information from a textbook, the learners, as I perceived it, would never be able to adapt properly to higher education, or to any working place which demanded the ability to make judgements or to solve problems. It is my contention that learners must learn to think for themselves and be able to take decisions for themselves. The experience that I had with the learners that I taught in high school showed me that they lacked the competence to learn autonomously or think independently. I thought that once the basic skills have been consolidated, teaching science thinking skills and science content knowledge would become easier for the learners.

What I have narrated provides the background to my decision to do a doctoral study in education that might enable me to learn first-hand how to teach thinking skills and processes and enhance learning and thinking abilities. I wanted first to learn how to approach learning difficulties and cognitive development, and second, to be able to help children to become more independent learners by providing them with the strategies and thinking skills to do so. I wanted to introduce changes to my own practice and learn how to teach thinking skills and help learners develop cognitively, which I thought was the most important objective of education. I strongly believed that learners' potential could be fulfilled and that I could make the difference by helping them to change. These desires motivated me to involve myself in processes of educational change and improvement, which I shall discuss in greater detail in the next section.

1.4 Motivation

Personal circumstances led to my arrival in South Africa in 2001. After arriving in this country I decided to continue with my attempts to learn how to approach problems relating to the acquisition of thinking skills in science. My interest in this respect was guided by a passion to find out how better to incorporate thinking skills into science education programmes, so that I would not struggle in the future with similar difficulties I had experienced whilst teaching in Israel. I was keen to learn how the problems related to the inadequately developed thinking skills of learners could be overcome.

I explained the desire to learn how to teach thinking skills in science to Prof. Carl, who was the Chairperson of the Department of Didactics in the Faculty of Education at the University of Stellenbosch. He introduced me to my promoter Prof. Lesley le Grange, who guided my research throughout my studies, and my co-promoter, Prof. Cilliers. When Prof. Cilliers heard of my research interests he advised me to meet Prof. Rautenbach, who knew both Frankenstein and Feuerstein personally, and shared with me his experiences after being introduced to Feuerstein's work. Being inspired by Feuerstein's work myself, I decided to attend an Instrumental Enrichment course as well as to complete a Postgraduate Diploma in Education (PGDE) at Stellenbosch University. One of the modules I attended introduced me to some of the great theoreticians of cognitive development, among others, Vygotsky and Feuerstein, and some of the most famous programmes oriented towards teaching thinking skills to learners with a wide range of abilities.

One of my first interests was to look at the reasons why some learners develop better cognitively than others. In this respect Frankenstein, Vygotsky and Feuerstein offer similar explanations relating to specific conditions that affect the developmental stages of learners. Apparently learners with special needs and underprivileged learners manifest similar problems, such as an inability to select relevant versus irrelevant cues in defining a problem, lack or limited use of spontaneous comparative behaviour and episodic grasp of reality, low motivation and so on [(Arbitman-Smith and Haywood 1980) p. 54]. Both Vygotsky and Feuerstein recommended Mediated Learning Experience (MLE) for both groups of learners as a way for these learners to develop basic thinking skills. The theoretical explanations of these authors persuaded me that the MLE might be very important for learners' cognitive development and that even a late provision of MLE can help learners become more independent and develop to become more autonomous learners.

The above-mentioned experience provided me with the motivation for initiating a study on teaching thinking skills and processes in science to learners with special needs. The intervention programme included a mediated teaching style and selected Instrumental Enrichment exercises to consolidate basic thinking skills and adapted science material emphasising on science thinking skills. Since I felt that the experience I had as a science teacher was too short and a bit limited, it was important for me to teach part of the intervention programme, as well as to evaluate the effectiveness of a different teaching style on learners' performances as well as the demands such a programme will place on me as a science teacher. In discussions with my promoter, Prof. Lesley le Grange, we decided that *Action Research* might be an appropriate research approach which I could use to conduct my research. In this investigation therefore I take on the role of teacher-researcher.

1.5 Conducting Action Research: Change in Paradigm

Being a scientist shaped the way I thought and believed research should be conducted. According to the natural sciences paradigm, research should be done under controlled conditions, changing one variable at a time and evaluating the consequences of this change on the working system. It relies on statistical manipulation of the data and will usually be conducted in comparison to specific known references. Thus, control and experimental groups are crucial in validating the data.

This approach to research, which I learned as a molecular biologist, was imprinted on my mind when I commenced this current study. Confronted with the idea of working within a different approach was difficult, since I had well-established empiricist beliefs, and struggled to accept another way of perceiving reality. Nevertheless, as I continued my social research studies at Stellenbosch University, I became familiar for the first time with alternative research paradigms.

For example, Hopkins (1993) writes that as teachers 'our emphasis is on varying teaching methods to suit individual pupils in order to help them achieve to the limit of their potential' [(Hopkins 1993) p. 39]. This will influence the pupil-pupil and pupil-teacher interactions, and learning will depend on the quality and engagement of the individuals in the interaction. Naturally, the learning-teaching situation will vary from one teacher to another and its success or failure will depend on numerous variables such as teacher's personality, learner's socio-economic background, school ethos, etc., none of which can be controlled or replicated. Stenhouse (1979) claims that education is 'successful to the extent that it makes behavioural outcomes of pupils unpredictable' and therefore not generalisable. The implication of Stenhouse's claims, according to Hopkins (1993), is to 'encourage teachers-researchers to look outside the psycho-statistical paradigm for their research procedures' [(Hopkins 1993) p. 40].

As I read more about action research, other paradigms not only began to sound appropriate to me, but I also found out that I could more easily identify with a critical-emancipatory paradigm for the following reasons:

(a) It seemed that my ideas of teaching thinking skills to learners with special needs are commensurate with some of the emancipatory ideals evident in the literature I reviewed. I say this because the approach that I undertake in the study might allow the children opportunities to become independent learners by developing the tools and strategies to think for themselves, which in turn may emancipate learners from societal constraints [(Hopkins 1993) p. 35];

(b) My willingness to change and improve my own practice is integral to professional development, which Hopkins (1993 p.35) claims contributes to the liberation and emancipation of teachers. In this regard developing teaching material as well as conducting research are processes known to be empowering for teachers, normally leading to professional growth, development and therefore emancipation [(Carl 1995) p. 8];

(c) Adopting a teacher-researcher point of view, which demands a critical evaluation of the self, the teaching practice and the effectiveness of the intervention programme, and an aim to develop or improve people's actions and understanding the situation through collaborative action also fits into this paradigm [(Babbie and Mouton 2001) p. 59, (Potter 1999) p. 219].

Inspired by Stenhouse's (1979) statement that 'The teacher is like a gardener who treats different plants differently, and not like a farmer who administers standardised treatments to as near as possible standardised plants' [in (Hopkins 1993) p. 40], I decided to engaged in *Action Research* study.

I read about *action research* as a method for teachers-researchers to conduct research *in situ* for the purpose of improvement and change of practice. It is known to be a way to evaluate intervention programmes by formative evaluation, while introducing changes as the programme proceeds for improvement and benefit of the learners who participate in the intervention programme. The more I familiarised myself with this approach, the more I was convinced that it is the form of research I was going to use.

It implied the use of specific techniques and roles, such as the role of a teacher-researcher, videotaping the entire lessons for the purpose of observation and validation, and collaborative work with other teachers. It demanded a programme design and material development, as well as development of means to assess scholastic achievement and the development of thinking skills and processes. I was motivated to engage in these activities, since it was my initiation, my own exploration into my own practice and into the learners' development.

I shall now elaborate further on some of the theoretical background that influenced this study.

1.6 Theoretical Influence

As mentioned Frankenstein was one of the first theoretician's work that I was exposed to and he was one of the few individuals who was sincerely concerned with the integration of Israeli society and making it more equal. He theorised about the etiology of underprivileged learners and claimed that under conditions of poverty, neglect, chance addiction and parental inconsistency children are prone to develop external instead of internal tension, univalent instead of ambivalent feelings, aggressiveness and resentments instead of mental conflicts [(Frankenstein 1979), p. 13]. He described specific symptoms that underprivileged learners manifest such as associative thinking, concrete thinking, weak sense of responsibility, dependence on authorities and insufficient rationalism [(Frankenstein 1979) p. 19-28].

Frankenstein recommended a specific teaching style in order to help learners develop to their full potential. His intensive programme aims to replace a false sense of security by encouraging the learner that 'he [*sic*] is able to orient himself [*sic*] adequately in a complex world of similar and different phenomena, through his [*sic*] own power of differentiation and generalisation' [(Frankenstein 1979) p. 30]. Furthermore, his programme offers a non-inductive teaching style, enhancing metacognition and thinking skills, a 'branching-out' teaching style, which aims to link the learners' 'irrelevant' associations with the subject matter and help the learner create his/her own meaning for the subject matter by connecting it to previous knowledge. In general it provides learning strategies which help learners develop scholastically, acquiring the skills and competence they might have missed as children.

Frankenstein's strategies can be implemented in a heterogeneous class, although he personally thought that working with a homogenous class is a more effective way of teaching. He claimed that trained teachers will be able to identify the types and origins of mistakes that underprivileged learners make and, as the lesson progresses, use the mistakes as opportunities for learning to occur.

As much as his teaching strategies were ideal and appealing to me, they were very difficult to apply while I was teaching high school learners in Israel. It demanded an ability to identify cultural and contextual differences and address them immediately in such a way that would provide a learning opportunity for all the learners. Apparently with time and practice, as well as a sound perception of different cultures and backgrounds, teachers can become proficient in this teaching style.

In my continuous search for strategies to teach thinking skills, I became familiar with Feuerstein's work through the Instrumental Enrichment (IE) course I attended in South Africa. Based on his assessments of learners who immigrated to Israel in the 1950s and who struggled to adapt scholastically, Feuerstein developed a theory regarding the cognitive development of children. He believes that cognitive development depends on direct exposure to stimuli, but also depends to a large extent on human mediators that help the child understand the world, its rules and functioning. He referred to this type of learning as a Mediated Learning Experience (MLE), and regards it as the main factor responsible for cognitive development. However, some learners fail to acquire the basic mental operations in the usual fashion through direct exposure to, or provision of, MLE and therefore manifest cognitive dysfunctions. A few of these are cognitive dysfunctions, such as an inability to select relevant cues in defining a problem, lack or limited use of spontaneous comparative behaviour, an episodic grasp of reality, lack of knowledge and events and so on [(Arbitman-Smith and Haywood 1980) p. 54]. These cognitive deficiencies are commonly found among slow learners, like mildly and moderately mentally retarded, children with learning disabilities, learners with emotional disturbances, learners who are socially alienated, learners who are culturally different or denied the developmental benefits of their own culture [(Arbitman-Smith and Haywood 1980) p. 54].

Feuerstein suggests that with the provision of MLE, even at later stages, all learners will be able to fulfil their potential. His IE intervention programme intends to help learners to develop different basic skills and processes, which might, in turn, help the learners to re-develop their cognitive functions. I find this a promising approach to consolidate basic skills, which in turn may enable learners with special needs to acquire and master thinking skills and processes in science.

Vygotsky, a Jewish psychologist, specialised in cognitive development and worked with learners with special needs. His work contributed to the understanding of children's' cognitive development, but was revealed to the West only in the 1960s. Vygotsky referred to mediated learning as the means of developing higher mental processes, and suggested psychological tools such as language, signs and symbols, and regarded human beings as the providers of mediated learning. He suggested that adults teach these tools to children in the course of their joint activities, the children would internalise them and these tools then function as mediators of the children's more advanced psychological processes [(Karpov and Haywood 1998) p. 27, (Kozulin and Presseisen 1995) p. 68]. Vygotsky also acknowledged the advantage of peer teaching-learning situations and developed the concept of the Zone of Proximal Development (ZPD). The ZPD refers to the situation when a child is confronted with a problem that cannot be solved on his/her own, but can be successfully solved with the help and guidance of an adult or a peer who just mastered it [(Wells 1999) p. 1].

Vygotsky believed that the ability to fully develop the cognitive functions of learners with special needs depends on the learning environment which trained teachers-educators are willing to provide and the efforts they are willing to invest in learners with special needs [(Gindis 1995) p. 79]. Vygotsky specifically claimed that the focus of compensation should be the intensification of cultural enlightenment, the strengthening of the higher psychological functions, the quantity and quality of communication with adults and the social relationship with a collective (an organised group of peers) [(Gindis 1995) p. 79].

These great theoreticians in cognitive development have inspired me by planting the seeds of hope and encouragement that have persuaded me that I can provide better instruction, which might change the reality of learners with the range of problems they are currently facing.

1.7 Summary

In this chapter I tried to sketch the background to, and the motivation for, conducting this research. My desire to understand how learners' cognitive development takes place, as well as the will to change cognitive dysfunctions and re-develop thinking skills, have led me to explore these issues.

My experience as a science teacher made me aware of certain needs among learners, which initiated a will to change my practice and improve my abilities to mediate so as to provide better teaching-learning environments for learners with a wide range of abilities.

Chapter One outlined the problem and, provided an autobiographical account so as to highlight my own need for change, driven by my experience as a science teacher. In

Chapter Two I will review the literature related to three domains of this study: (a) trends in science education, and specifically the change from a content-led approach to a process-led approach and associated research, (b) The etiology of learners with special needs and their special status in South Africa, and (c) Feuerstein's and Vygotsky's concepts of mediation and Instrumental Enrichment as an intervention programme to develop thinking skills and processes. **Chapter Three** will present several different methodologies in social sciences, explain the use of *Action Research* as a paradigm to evaluate intervention programmes, and indicate in particular how this study was framed within a critical emancipatory paradigm. I introduced an intervention programme with an emphasis on teaching thinking skills and processes in science to learners with special needs in two classes of Grade 5 and 6 learners. The intervention programme design, implementation and evaluation will be discussed in this chapter as well. In **Chapter Four** I will describe in detail the findings of the intervention programme, as I perceive them, using techniques such as observation and triangulation, produced over two cycles of inquiry presented as two case studies. In **Chapter Five** I provide an interpretation of the findings, and highlight emerging themes with regard to the objectives of the study as well as issues which might throw greater light on South Africa's recent curriculum policy development.

Chapter Two

Teaching Thinking Skills to Learners with Special Needs – An Overview

2.1 Introduction

Individuals in a competitive society like ours must be able to adapt, take decisions for themselves, solve problems and plan ahead, knowing why they are acting in a specific way, and what else must they figure out before they actually take an action. They must be able to think. Therefore, one of the roles of the educational system is to prepare learners to develop their abilities to do just this.

The attempts to help learners become better thinkers by promoting the development of thinking skills and processes are the focus of this literature review. I will discuss different perspectives on thinking skills and processes, the theories of cognitive development and the development of thinking skills programmes. Also, I will present some of the ways in which researchers integrate and combine thinking skills in education generally, and in science education and special education in particular.

I start by giving an historical background to the content-led approach to science teaching and some of its shortcomings, followed by a review of the development of the process-led approach.

2.1.1 The Content-Led Approach

For many years science teaching has been dominated by the transmission of content knowledge to learners. School science education programmes were designed mainly to meet the needs of higher education and therefore became the route for training scientists [(Kirkham 1989) p. 135]. Over the years more and more content knowledge was included in school science syllabuses. The emphasis was on learning and memorising names and definitions, symbols and formulae, theories, models and terminology, and understanding the associated concepts [(Kirkham 1989) p. 136]. For example, Biology instruction was based on the requirements for the pre-medical curriculum with an emphasis on anatomy, morphology and dissection [(Jenkins 1989) p. 37] in Britain. External examinations for the science disciplines were seen as very difficult and were based on recall of content knowledge and related concepts [(Kirkham 1989) p. 135-6]. This, in turn, also forced teaching to be oriented towards delivering content [(Screen 1986) p. 13].

The content-led approach was very suitable for learners who continued to higher education in science disciplines and many scientists and engineers began their training through science at school [(Kirkham 1989) p. 148-9]. However, it was not an approach that could meet the needs of all learners. Many learners in the past were discouraged by science, finding it uninteresting; they were poorly motivated to know it and in some cases were even baffled by it [(Wellington 1989) p. 7]. For some learners the curriculum was irrelevant to their lives, being too abstract and remote [(Kirkham 1989) p. 135-6]. Consequently, many learners avoided studying science courses or discontinued their science studies, and girls in particular reacted negatively to the way the physical sciences were presented [(Kirkham 1989) p. 148].

The content-led approach was not only irrelevant to learners' needs, but also impacted negatively on learning. For example, the Newsom Report (1963) found only a few examples of traditional science teaching that were suitable for meeting the needs of the 'average and below' ability learners [(Kirkham 1989) p. 135]. Simpson (1987) claims that only a minority of learners understood and effectively used concepts and content in science. He writes that 'the majority (of learners) failed to attain the level of mastery of school science which would allow them to proceed to certificate courses; of those who did, some failed to achieve levels which would allow any recognition of attainment, and many were awarded certificates on the basis of performance, which if described in criterion referenced terms, indicated that 50 per cent of their expected knowledge was either faulty or non-existent' [(Wellington 1989) p. 8].

Another reason for the failure of the content-led approach was the explosion of science information, especially in subjects like computers and biology during the last few decades [(Screen 1986) p. 13]. It has been argued that scientific knowledge is being produced at too fast a rate to form a basis for inclusion in science education programmes.

The amount of knowledge that can be taught and recalled in tests and examinations is only a small proportion of the whole and might also be dated at the time it is taught or become dated shortly afterwards [(Screen 1986) p. 13]. Knowledge has become very accessible through computer searches, so what is required from science learners is rather 'the ability to access, use and ultimately add to the information store when required' [(Screen 1986) p. 13].

Since it seemed that the content-led approach was no longer suitable, alternative ideas started to emerge, parallel to the development of some very significant theories regarding education and development. The rationale for the development of the process-led approach, which followed the content-led approach, is elaborated in the next section.

2.1.2 The Development of the Process-Led Approach

In the 1960s science curricula changed dramatically due to emerging theories and new trends that influenced the development of an alternative approach to teaching science. I will discuss briefly Blooms' Taxonomy, which laid the basis for curriculum development; Piaget's theory of the way that children develop cognitively; and the '*discovery approach*' as a way to teach science concepts. These served as the main theories that influenced the development of what has become known as the process-led approach to science teaching.

2.1.2.1 Curriculum Development and Domains of Learning

General analysis of how a curriculum should be designed, which formed the basis of a new academic field called 'curriculum theory', led to the development of a model in which objectives and evaluation became part of curriculum planning [(Jenkins 1989) p. 39]. In this respect, cognitive, psychomotor and affective domains were taken into account when developing instructional objectives. Krathwohl's affective taxonomy represents a progression of capabilities leading to learning outcomes in the affective domain, which relate to changes in attitudes and values about the things one learns [(Ormrod 1995) p. 425]. Harrow's psychomotor taxonomy refers to learning outcomes for the psychomotor domain, and considers simple and complex physical movements and actions that can serve as educational objectives [(Ormrod 1995) p. 423]. The cognitive domain includes knowledge of information as well as ways of thinking about and using this information. Bloom's taxonomy has been one of the most influential publications regarding the cognitive domain, and has been used widely in terms of stating objectives and evaluations accordingly and is still used today [(Fisher 1990) p. 70, (Ormrod 1995) p. 423]. Bloom's taxonomy consists of six levels, which classify the cognitive levels of students' behaviour from concrete to abstract, and include knowledge, comprehension, application, analysis, synthesis and evaluation [(Cotton 2000) p. 3]. Bloom's taxonomy was widely applied in curriculum guides and is manifested by tests that not only evaluate content but also comprehension, application, analysis, etc. This classification can also be used to plan instruction based on learning outcomes.

2.1.2.2 Cognitive Development and Constructivism

Piaget, a Swiss psychologist, developed a theory about how children learn and develop cognitively, known as *Constructivism* [(Donald *et al.* 1997) p. 42]. According to Piaget, any individual is constantly confronted with new stimuli and events that help the individual construct his/her own body of knowledge which explains how the world operates [(Feuerstein and Feuerstein 1991) p. 9]. This process involves ongoing mental activities of adaptation through two main mental processes: assimilation and accommodation. Assimilation occurs when the individual encounters new information and fits it into an existing concept or schema (an organised group of similar actions or thoughts). When new information cannot be fitted, or it contradicts an existing concept or schema, the child is confronted with a mental discomfort known as a dis-equilibrium state. This in turn makes the child either adjust his/her old schema so that the new knowledge will fit in, or create a new schema altogether [(Ormrod 1995) p. 36]. Re-organising knowledge, finding new explanations and escaping the state of dis-equilibrium (which becomes equilibrium again) is known as the process of accommodation, and promotes the development of more complex levels of thought and knowledge [(Ormrod 1995) p. 36-7]. Therefore, Piaget' theory is sometimes called *Constructivism*, because the learners construct their own knowledge from their own experience [(Watson 2000) p. 135-6].

Piaget's theory influenced the science curriculum in the sense that for effective learning to occur, learners must be exposed directly to situations in which they cannot explain new information using their old schema, or basically situations of dis-equilibrium are created. Kuhn claims that research has shown that children and adults hold a variety of naive, intuitive conceptions, usually misconceptions, about how the world works, and which are not necessarily the accepted scientific explanation of how the world works [(Kuhn 1989) p. 675]. These misconceptions are powerful and very resistant to instruction; the only way to change them, according to Kuhn, is by creating a state of dis-equilibrium, and by contrasting these misconceptions with scientific concepts. Only then might the child acquire new knowledge and gain an understanding of scientific concepts [(Ormrod 1995) p. 37, (Kuhn 1989) p. 675].

2.1.2.3 The Discovery Approach

In line with Piaget's theory, Bruner (1960) thought that learners can better understand and appreciate the ways in which the world is predictable when they actually observe such principles in action. Therefore, science must be taught in a way that reflects and illustrates the conceptual and methodological structure of science itself [(Ormrod 1995) p. 443; (Jenkins 1989) p. 40]. Bruner's ideas as well as Piaget's were manifested through programmes with an emphasis on "discovery" or "investigative" learning, which to some extent enabled learners to become scientists themselves [(Jenkins 1989) p. 38]. In the *discovery approach* to learning learners develop an understanding of a topic in a 'hands-on' fashion through their interaction with the physical or social environment [(Ormrod 1995) p. 442]. The discovery approach was criticised too [for example, (Kuhn 1989) p. 675; (Millar 1989) p. 50, (Ormrod 1995) p. 444,], mainly because self-inquiry by learners as a way to reveal scientific laws and concepts was shown to be insufficient to develop learners' deep understanding of science. However, the self-inquiry approach or the discovery approach, with modifications, is still the core of science education today (for example, in Curriculum 2005, which advocates experimenting and a hands-on learning style). This is because learning occurs through the active participation of learners exploring scientific phenomena (*discovery approach*), which helps them make new knowledge meaningful by relating it to previous knowledge (*Constructivism*) in the process of building and rebuilding concepts [(Ormrod 1995) p. 442; (Watson 2000) p. 136; (Miciikas 1996) p. 433].

2.1.2.4 The Process-Based Approach

Gagné believed that the processes whereby learners learn science are essentially the same as those whereby science is advanced [(Jenkins 1989) p. 40], and he developed a focused approach on learning processes, referred to as the process-led approach.

This approach, which places an emphasis on teaching thinking skills and processes, became known as the 'process-led' science curriculum.

The importance of teaching thinking skills and processes is the notion that for learners to become better thinkers and to decide rationally what to do or believe, they must be provided with more than just knowledge [(Norris 1985) p. 40]. Problem-solving and decision-making abilities, which are necessary in everyday situations, are based on mental processes and cognition that allows the individual to solve problems successfully or take decisions rationally. Costa (2004) claims that creative and innovative thinking are important thinking skills to problem solving [(Costa 2004) p. 6]. Often this requires the development of strategies and attitudes to function alongside knowledge and understanding. If learners are to take intelligent decisions, they ought to be able to solve novel problems by applying information, interpreting new data, making predictions and drawing conclusions [(Moll and Allen 1982) p. 95], or by producing reliable observations, making inferences and formulating hypotheses [(Norris 1985) p. 40].

Processes and skills in this respect are the building blocks of rational thinking and the means to become a better thinker, and may be considered as indispensable parts of an education because 'being able to think critically may be a necessary condition of being educated' [(Norris 1985) p. 40]. Norris goes as far as suggesting that it is the learner's '*moral right* to be taught how to think critically' [(Norris 1985) p. 40 (italics in the original)].

These arguments were supported in many parts of the world in the 1980s and 1990s. For example, Screen (1986), who presented the Warwick Process Science Project (which was a process-led orientation), writes: 'understanding, skills, processes, application and communication…are the qualities of science education, which will be of value when the facts are out of date or forgotten' [(Screen 1986) p. 13]. This notion was also supported by Adams (1993), who writes: 'In most cases, especially for non-science majors, students forget specific subject-matter objectives… Skills and attitudes remain with students and continually influence their personal and professional lives' [(Adams 1993) p. 100]. Norris (1985) emphasises that there is a responsibility to teach learners to question, challenge and demand reasons and justifications, 'because in the end students must choose for themselves; there is no escaping this truth' [(Norris 1985) p. 40].

Supporting the process-led approach, however, does not mean neglecting teaching content knowledge, although it may be misconstrued to be the case. For example, Screen did not suggest that knowledge should be disparaged or that it is unnecessary. On the contrary, Screen specified that processes cannot be taught in vacuum, but should rather be taught in science contexts; this includes important concepts and vocabulary that are fundamental to understanding science [(Screen 1986) p. 14]. Norris claims that critical thinking skills are not substitutes for experience, common sense and sound knowledge of subject matter, and that critical thinking skill cannot compensate for lack of knowledge in the area in question [(Norris 1985) p. 44]. Teaching thinking skills and processes in a context of the specific content of a subject matter or discipline is well supported in science education literature (Kirkham 1989; McPeck 1981; McPeck 1990; Norris 1985; Costa 2004).

However, the process approach is promising, since its proponents claim that skills, particularly transferable skills, are more relevant to learners than merely acquiring content knowledge [(Screen 1986) p. 13-14, (Costa 2004) p. 1]. Furthermore, the thinking skills and processes programmes are said to be more accessible to learners of a much wider range of ability than more traditional approaches to science education would seem to allow [(Screen 1986) p. 15, (Jenkins 1989) p. 42, (Costa 2004) p. 1].

I will now turn to discuss what are considered as processes and thinking skills, different opinions regarding their transferability to other learning areas and to what extent this is possible, and two main educational strategies by which educators teach thinking skills and processes. In the next section the terminology related to thinking skills and processes generally, and in a science context in particular, will be presented.

2.1.3 Skills and Processes

The ability to think and use thinking skills effectively and efficiently was regarded for many years as genetically determined with no possibility of changing or improving learners' abilities in this regard. Ristow (1988, p.44) notes that these capacities have been regarded as 'A fluke of nature, a genetic predisposition… qualities that are either possessed or not possessed by their owner, and that education can do very little to develop these qualities' [in (Cotton 2000) p. 2].

However, doubts about the validity of the concept of primary genetic control over intellectual performance have been expressed during the last few decades [(Feuerstein *et al.* 1981; Gindis 1995; Warsham and Austin 1983)]. Moreover, it has been suggested in a wide range of programmes that one could learn how to think and that thinking skills can be taught explicitly and improve with time [(Costa 1991); (Costa 2004)].

It is hard to find a consensus definition for the terms 'processes' and 'skills', although they are used frequently in the literature. Therefore, I shall refer to a few different definitions in the discussion that follows.

Harlen provides a broader definition of process-skill as any cognitive-process involving interaction with content [(Wellington 1989) p. 18].

Alvino (1990) defines 'thinking skills' as the set of basic and advanced skills and sub-skills that govern a person's mental processes. These skills consist of knowledge, dispositions and cognitive and metacognitive operations [in (Cotton 2000) p. 3].

South Africa's Revised National Curriculum Statement defines 'process-skills' as 'the learner's cognitive activity of creating meaning and structure from new information and experiences' [(Department of Education 2002) p. 13].

Many writers distinguish between two types of thinking: critical thinking, also called logical or analytic reasoning, and creative or exploratory thinking. Alvino (1990) defines 'critical thinking' as a process of determining the authenticity, accuracy or value of something; it is characterised by the ability to seek reasons and alternatives, perceive the total situation, and change one's view based on evidence [in (Cotton 2000) p. 3]. McPeck (1981) claims that 'critical thinking involves a certain scepticism or suspension of assent, towards a given statement… and does not take truth for granted' [(McPeck 1981) p. 5-6].

'Creative thinking' according to Alvino (1990) is 'a novel way of seeing or doing things' [in (Cotton 2000) p. 3]. It is characterised by four components: *Fluency* - generating many ideas; *Flexibility* - shifting perspective easily and overcoming mental blocks; *Originality* - conceiving of something new; and *Elaboration* - building on other ideas [(Fisher 1990) p. 44-47]. These are known as important thinking skills for effective problem solving and decision making [(Costa 2004) p. 8].

In the context of science education Millar and Driver (1987) categorise skills and processes as 'the processes scientists use in investigating the natural world, the cognitive processes involved in learning, and pedagogical processes taking place in the classroom' [in (Jenkins 1989) p. 21]. Although Millar himself argues that 'these processes have no special link with science but are simply convenient labels for general approaches which we all use all the time in making sense of the world' [(Millar 1989) p. 49], he does state that all scientists use these skills; for example, they observe, propose hypotheses, and so on.

Although science programmes include different sets of skills and processes in their package of cognitive activities, all of them seem to incorporate what Gagné (1970) defines as representative of problem solving [in (Shaw 1983) p. 615].

For example, in the Introduction to *Warwick Process Science,* Screen (1986) listed the processes made explicit in their course as: observing, inferring, classifying, predicting, controlling variables, and hypothesising [(Screen 1986) p. 14]. Science in Process (ILEA, 1987) listed the following process-skills: applying, interpreting, classifying, investigating, evaluating, observing, experimenting, predicting, hypothesising, raising questions, and inferring [in (Millar 1989) p. 47]. Nuffield (11-13, 1986) listed the following skills: handling equipment, observing, 'patterning' (which includes classifying and predicting), communicating, designing investigations (which includes raising questions, hypothesising and controlling variables), experiments and mental modelling [in (Millar 1989) p. 47-8].

According to the Revised National Curriculum Statement of South Africa (2002), process-skills can be seen as the building blocks from which science tasks are constructed and as the means by which the learners engage with the world and gain intellectual control of it through the formation of concepts [(Department of Education 2002) p. 13]. Furthermore, it specifies these processes and skills: observing and comparing, measuring, recording information, sorting and classifying, interpreting information, predicting, hypothesising, planning science investigations, conducting experiments and communicating science information [(Department of Education 2002) p. 13].

The Commission on Science Education of the American Association for Advancement of Science (AAAS) defined and divided the skills which Gagné (1970) defines as representative of problem solving into two groups [in (Shaw 1983) p. 615]:

- Basic processes including observing, measuring, inferring, predicting, classifying and collecting and recording data;
- Integrated processes including interpreting data, controlling variables, defining operationally, formulating hypotheses and experimenting.

Since it is in line with the South African list, the AAAS division will inform my work, although other processes and skills lists may also be acceptable. In the next section a definition of the term 'transfer', as well as issues regarding the transfer of thinking skills, will be elaborated upon.

2.1.4 Transfer

The term 'transfer' is often associated with processes or thinking skills, but also with knowledge. Alvino (1990), defines transfer as 'the ability to apply thinking skills taught separately to other subjects or disciplines' [(Cotton 2000) p. 3].

There is an ongoing debate as to whether it is really possible to transfer knowledge or skills. Adams (1991) explains that when a person thinks within a particular schema, his/her thoughts do not wander to another schema, because of a mechanism that protects the individual from unrelated associations and the mental chaos that would result from this. The exact same mechanism that protects the individual from jumping between schemas inhibits transfer and therefore, according to Adams, it is not surprising that transfer effects tend to be weak when thinking skills are taught in conjunction with a particular content area. The content area serves as the context within which the thinking skills will be retained and through which they may be recalled [(Adams 1991) p. 1]. Consequently, she argues that it is possible to access these skills through explicit and related analogy to that context. In this respect she claims that in order to maximise transfer, the materials and content that serves as the context for the development of thinking skills should be as diverse and as broadly useful as possible. This may enable learners to transfer the skills when confronted with novel problems by applying them in a rational and productive way [(Adams 1991) p. 2].

McPeck (1990) argues that the critical thinking skills do not effectively transfer to any significant degree. He claims that the more general the strategy, the experimental method or the rule of thumb is, the less easy to transfer or the less useful they are for solving a particular problem. Contrariwise, the more specific a method, strategy or solution is, the more applicable to other problems it might be [(McPeck 1990) p. 14-15]. Therefore, he argues that some kinds of specific knowledge and information could be transferred [(McPeck 1990) p. 15-16].

Feuerstein considers the issue of transfer from a slightly different angle. Feuerstein contends that thinking skills should be taught explicitly and practised in a 'content-free' context for several reasons, which will be discussed later in the chapter [(Feuerstein *et al.* 1981) p. 274]. According to Feuerstein's theory, after teaching thinking skills explicitly, the principles must be bridged or explicitly transferred to specific and general contexts by the teacher-mediator. The learners should be encouraged to think of different applications in life where they can make use of the thinking processes and skills they have just learnt [(Fisher 1990) p. 143, (Haywood 1993) p. 35].

In general, the data indicate that, if the instruction is focused on helping learners become better problem-solvers by monitoring the approaches they use, and making them aware of the strategies they apply to solve tasks, transfer is more likely to occur [(Bransford, Burns, Delclos and Vye 1986) p. 70]. Zohar, Weinberger and Tamir (1994) indicate that under certain conditions the transfer of thinking skills can take place. They claim that by being exposed to multiple examples in different content areas and supplementing the examples with rules and generalisations, transfer might happen

[(Zohar *et al.* 1994) p. 184]. In other words, the success of programmes in which thinking skills are taught are the ones that include explicit and consistent labelling of principles and processes along with direct instruction of when, where, why and how to apply them (i.e. explicit transfer of thinking skills) [(Adams 1993) p. 2].

There are a few factors that affect transfer [(Ormrod 1995) p. 375-385]. The first factor concerns the amount of instructional time. The more time learners spend studying a particular topic, and the more examples and opportunities they have to practice it, the more likely they are to transfer what they have learned to new situations. Second, if the learning is meaningful (rather than entailing rote learning), connecting it to other things that are already known, and by teaching principles and rules rather than facts, transfer is more likely to occur. Third, if there are enough similarities between two situations, or the cues that are given are relevant, in the sense that they help to retrieve the related knowledge (as was mentioned before as an explicit and related analogy to that context), transfer might happen. Last but not least, if a topic is related to other disciplines or to other situations in life, the topic tends to be context-free and can be more available for use by the learners.

In the next section I will present a literature review of evaluations of programmes with an emphasis on thinking skills and processes, and discuss their findings in terms of scholastic performance, IQ improvement and transfer in order to provide some published data which supports the use of such intervention programmes. Also, I will review some programmes from Costa's book (1991) *Developing Minds*, which serves as a resource book for programmes on the teaching of thinking skills.

2.1.5 Developing Thinking Skills Programmes

Cotton (2000) published a literature search called 'Teaching Thinking Skills', which summarises 56 documents, including research studies and reviews, all of which describe the effect of instruction in the process-led approach, with an emphasis on skills and processes, as well as metacognitive functions such as problem solving and decision making. She reviewed studies in science education as well as reading comprehension, mathematics, social studies, etc. Learners differed in their age, IQ scores, ethnic groups, urban, suburban and rural settings, and different socio-economic backgrounds.

Cotton's main finding is that providing learners with thinking skills instruction is important because it promotes intellectual growth and academic achievement. Moreover, she claims that research evaluating 'thinking skills' programmes found a positive difference in the achievements level of participating learners, and brought about improvement in learners' performance on intelligence and achievement scores. She points out that studies which looked at achievement over time show that thinking skills instruction accelerates the learning gains of participants and that experimental learners outperformed controls to a significant degree [(Cotton 2000) p. 4-5].

In his book *Developing Minds* Costa (1991) gathered about 30 articles describing different programmes and it may thus serve as a resource book for teaching thinking in all disciplines. Many of the major programmes are designed to develop thinking skills, such as: *Instrumental Enrichment* (*IE*), *Odyssey: A Curriculum for Thinking* (*Odyssey*), *Philosophy for Children*, *COGNET* and the *CoRT Thinking Programme* by de Bono and many others. The book (Costa 1991) identifies the audience for whom each programme is intended, with the programme objectives and goals as well as practical details. A few of these programmes emphasise the importance of making implicit thinking more explicit [(Vye and Bransford 1981) p. 26] such as *IE*, *COGNET* and *Odyssey*. Other programmes teach those skills implicitly through other activities designed to provoke thinking, such as *Philosophy for Children* and de Bono’s *CoRT Thinking Programme*. The principle is that by focusing on these processes (either explicitly or implicitly), learners will develop general skills, which they can then apply to novel problems in new areas [(Adams 1991) p. 2; (Costa 2004) p. 1]. Another common characteristic is helping learners become aware of the thinking processes they use as they attempt to solve problems. This is called metacognition, which is thinking about thinking, learning and remembering, and part of being able to improve thinking skills is being aware of these processes. Metacognition improves learners' ability to solve problems later on [(Vye and Bransford 1981) p. 26; (Costa 2004) p. 4]

Sternburg and Bhana (1986) tried to evaluate the effect of 'thinking skills' programmes such as *IE*, the *Odyssey* curriculum, *Philosophy for Children* and others. In general, they criticised the studies evaluating these programmes on the basis of arguments such as the following: 1) Many of the studies were conducted or sponsored by the programme developers; 2) The reports on the studies were usually sketchy and often wholly inadequate; in the most cases there was insufficient detail for replication; 3) Many studies did not have proper controls and some entitled none at all; 4) Outcome measures often overlapped with programme content, and thus favoured the programme being evaluated; 5) Many studies were not published in referred journals, which help in qualifying the methodology of the research; 6) Some of the results indicated gains and some did not, which were generalised as mixed results [(Sternberg and Bhana 1986) p. 61].

However, Sternburg and Bhana (1986) did conclude that 'there are enough positive results to suggest the potential for gains … and that the opportunities exist to increase students' thinking skills' [(Sternberg and Bhana 1986) p. 67].

One way to teach thinking skills is to incorporate them into the existing curriculum. Research support on the Infusion Approach and an explanation of what it is all about is the main theme of the next section.

2.1.6 The Infusion Approach

The infusion approach is an integrated approach in which the development of thinking skills is infused within regular disciplinary courses. It is based on the view that thinking skills should be taught in a knowledge-rich environment and the regular disciplinary courses may provide such an environment [(Zohar *et al.* 1994) p. 184]. McPeck supports this approach, arguing that 'thinking is always thinking about something… and manifests itself in connection with some identifiable activity or subject area and never in isolation' [(McPeck 1981) p. 3-5]. He argues also that critical thinking should therefore be taught as an integral part of other subjects [(McPeck 1981) p. 18].

Thinking skills have been integrated into the regular biology and science disciplinary courses, and different studies report higher achievements of learners in problem-solving tasks as well as in understanding knowledge and concepts in biology. Zohar, Weinberger and Tamir (1994), for example, identified seven skills that were selected as goals of the

Biology Critical Thinking Project (BCTP). The skills were selected because of their frequent use in both everyday life and in the study of Biology and were integrated into the regular Biology curriculum. The 'critical thinking skills' were: recognising logical fallacies, distinguishing between the findings of an experiment and conclusions made on the basis of them, identifying explicit and tacit assumptions, avoiding tautologies, isolating variables, testing a hypothesis and identifying relevant information. The experimental group which completed the BCT activity improved their critical thinking skills compared to their own initial level and compared to their peers in the control group [(Zohar *et al.* 1994)]. Other similar studies promoting critical thinking skills in science produced similar results (Moll and Allen 1982; Shaw 1983; Shayer and Adey 1992a; Shayer and Adey 1992b; Statkiewicz and Allen 1983; Warsham and Austin 1983).

In some of the studies it was reported that transfer of skills also had occurred. This may suggest improvement in thinking skills and problem-solving abilities in biological as well as everyday non-biological topics (Statkiewicz and Allen 1983; Zohar *et al.* 1994).

Some of the studies evaluated efforts to develop critical or formal thinking (Adams 1993; Chiras 1992; Novak and Dettloff 1989; Shayer and Adey 1992a; Shayer and Adey 1992b), while others were concerned with developing creative thinking (Lazarowitz and Huppert 1980). These will be discussed in the next section

2.1.7 Critical and Creative Thinking

The development of critical thinking has been regarded for many years as one of the major aims of education [Resnick (1987) in (Zohar *et al.* 1994)]. Zohar *et al.* (1994) also claim that it appears that critical thinking skills do not develop unless explicit and deliberate efforts are invested in developing them; in their study they show that teaching critical thinking skills is possible. Moll and Allen (1982) find that by using their instructional procedures, which are 'to stress the importance of student exploration ideas, interpretations, and various lines of reasoning in order to improve critical thinking skills', learners show improvement in their critical thinking ability and content knowledge.

A variety of approaches to teaching critical thinking skills were developed and used in a number of studies. For example, problem solving [in (McMurray and Beisenherz

1991; Moll and Allen 1982; Shaw 1983; Statkiewicz and Allen 1983; Zohar *et al.* 1994), and use of mini and issue-directed research projects, short essay examination questions and scenario-based research projects (Adams 1993; Novak and Dettloff 1989). Learners' reactions to these learning techniques have been positive, and they developed and improved their critical thinking skills.

One of the important components of problem solving is the use of divergent thinking or creative thinking. Science education makes use of the inquiry method, which in turn requires learners to engage in creative thinking, especially when hypothesising and elaborating new knowledge based on previously learned information (Lazarowitz and Huppert 1980). One of the studies that tried to develop creative thinking looked at three out the four criteria of creative thinking, namely training learners to produce as many ideas (fluency) of different types (flexibility) and originality (Lazarowitz and Huppert 1980). The authors presented a specific situation and asked learners to generate as many ideas, suggestions and hypotheses as possible. The authors found that the experimental group did significantly better then the control group in all three criteria, suggesting that combining creative thinking processes with the inquiry method is both possible and effective (Lazarowitz and Huppert 1980).

The ways to evaluate the success of intervention programmes can vary. In the next section the methods of evaluation of the studies presented earlier will be discussed.

2.1.8 Evaluating Thinking Skills

Most of the investigations used exams, mainly pre-tests and post-tests, to evaluate gains of programmes in critical and creative thinking skills. Some studies used well-established tests like Piagetian tests and the General Certificate of Secondary Education (GCSE) (Shayer and Adey 1992a; Shayer and Adey 1992b), or ACT and the Watson-Glaser Critical Thinking Appraisal (CTA) (McMurray and Beisenherz 1991), or the Scholastic Aptitude Test (SAT) and the California Achievement Test (CAT) (Warsham and Austin 1983). Using well-known tests increases the validity and reliability of the results; however, they do not necessarily evaluate the thinking skills that were taught. In other studies special creative and critical thinking tests were developed which test specific thinking skills, such as the Test of Critical Thinking in Biology (McMurray and Beisenherz 1991) or other unique tests (Lazarowitz and Huppert 1980; Moll and Allen 1982; Statkiewicz and Allen 1983; Zohar *et al.* 1994). These tests are administrated to evaluate specific outcomes of an intervention programme, but since they are not well established, they need to be qualified and accepted as valid tests.

In general, all studies show that learners in experimental groups improved their critical and creative thinking compared to learners in control groups (Lazarowitz and Huppert 1980; McMurray and Beisenherz 1991; Moll and Allen 1982; Shaw 1983; Shayer and Adey 1992a; Shayer and Adey 1992b; Statkiewicz and Allen 1983; Zohar *et al.* 1994). Moreover, Shayer and Adey, influenced by Piaget and Vygotsky, developed an intervention programme to develop formal operational thinking, called Cognitive Acceleration in Science Education (CASA). Effects yielded not only improvements with respect to the control groups' performance on the science achievements, but transfer to Mathematics and English also occurred [in (Klauer 2002) p. 165]. They also showed even higher achievements in tests taken two and three years after the interventions took place [(Shayer and Adey 1992a; Shayer and Adey 1992b)].

Only a few of the studies used formative evaluation by collecting solved problems throughout the intervention and testing every 3-4 weeks (Statkiewicz and Allen 1983). Others used questionnaires to evaluate opinions about the intervention of teachers and learners (Friedler and Tamir 1986).

In contrast to traditional ways of evaluating, other opinions about assessment have been voiced. For example, Zeidler, Lederman and Taylor (1992) suggest that:

> The development of critical thinking and decision making skills is not accomplished as the result of a single activity or unit. The accomplishment of such curricular objectives is a long-term proposition. Consequently, the classroom teacher will need to focus more on formative evaluation of thought processes within the evaluation plan as opposed to the more commonly used combination of summative measures [(Zeidler *et al.* 1992) p. 447].

This may suggest that summative evaluation is not sufficient to show progress in some acquired skills and processes, and formative evaluation should also be used in order to evaluate them properly.

Outcomes-based education is one system by which the process-led approach might be implemented. I discuss this in detail in the next section.

2.1.9 Outcomes-Based Education

Outcomes-based education (OBE) is a relatively old system (500 years) and refers to the outcomes expected at the end of the course [(Spady 1994) p. 1]. OBE is designed around preferred learning outcomes in a way that the curriculum, the instruction and the assessment are focused to ensure that all the learners will be able to succeed at the end of their learning experience. Some training schools use this approach, such as medical schools, law schools as well as the boy and girl scouts [(Spady 1994) p. 4].

Outcomes are clear learning results and not values, beliefs, attitudes or psychological states of mind; rather they are a tangible application of what has been learnt and reflect learners' competence in using content, information, ideas and tools successfully [(Spady 1994) p. 2]. Learners should be able to manifest them at the end of their learning period and they will serve as the 'exit outcomes' or 'culminating outcomes' [(Spady 1994) p. 18]. From the culminating outcomes further specific outcomes pertinent to a subject or academic area will be drawn. These outcomes are more specific and detailed and specify the expectations from different age groups and abilities.

The outcomes are written as statements describing what the learner should be able to know and can do. Since outcome-based systems expect learners to carry out the processes defined within an outcome statement, they are careful to build those processes directly into the outcome through a demonstration verb [(Spady 1994) p. 2]. For example, the demonstrating verb is in *italics* in these examples of outcomes:
Learners will:

1) *Identify* and *solve* problems and *make* decisions using critical and creative thinking;
2) *Work* effectively with others as members of a team, group, organisation, and community [(Department of Education 1997) p. 10].

The paradigm of OBE is based on the viewpoint that *What* and *Whether* learners learn successfully are more important than *When* and *How* they learned something [(Spady

1994) p. 8]. This viewpoint suggests that the schedule and methods by which one learns play a secondary role in achieving successful learning results. In this regard, the OBE system aims to be an inclusive educational system, based on the belief that all learners can learn and succeed, not necessarily at the same time or in the same way, and that providing a successful experience in learning leads to even more successful learning [(Spady 1994) p. 9]. Therefore the system is very flexible, allowing an extensive time schedule to achieve the desired outcomes, and permitting diverse teaching methods by which all learners will be able to achieve the desired outcomes. OBE emphasises progress according to individual potential by providing and supporting development through a variety of learning strategies, encouraging functioning according to optimal potential, and providing multiple learning opportunities [(Department of Education 1997) p. 16]. Levels and grades are viewed not as a restrictive, but rather as guidelines as to what should happen by the end of the phase concerned.

To conclude, the purpose of OBE (in theory) is to ensure that all learners are equipped with knowledge, competence and qualities which they need in order to be successful in life, and that these are partly provided by proper school facilities, flexibility in time and in teaching methods [(Spady 1994) p. 9].

The rationale, guidelines and development of the OBE approach in South Africa and the development of Curriculum 2005 will be described in the next section.

2.1.9.1 Outcomes-Based Education in South Africa - Curriculum 2005

With the policy of apartheid South Africa did not have one national education system, but rather education was the responsibility of a complex of 18 different and uncoordinated education departments. Those were divided across racial lines [(Donald 1994) p. 3]. Unequal distribution of resources led to discrimination against some population groups, which deprived them of a proper education [(Donald 1994) p. 4].

In 1995 a White Paper on Education and Training was published in South Africa. [(Republic of South Africa 1995)]. It was the first attempt to develop a policy to educate and train all the people of the country within a single education system. The curriculum was influenced by the process-led approach, and encouraged learners to develop independent and critical thought, the capacity to question, inquire reasoning, to weigh evidence and form judgements, to achieve understanding, to recognise the provisional and incomplete nature of human knowledge, and to communicate clearly [(Republic of South Africa 1995) p. 22]. This was also followed by a paradigm shift from a content-based curriculum to an outcomes-based education system [(Park and Cilliers 2002) p. 144].

Curriculum 2005 consists of seven broad and general Critical Outcomes (Culminated Outcomes) to ensure that learners gain the skills, knowledge and values that will allow them to contribute to their own success as well as to the success of their family, community and nation as a whole [(Department of Education 1997) p. 10]. The Critical Outcomes are to:

1. Identify and solve problems and make decisions using critical and creative thinking;
2. Work effectively with others as members of a team, group, organisation, and community;
3. Organise and manage themselves and their activities responsibly and effectively;
4. Collect, analyse, organise and critically evaluate information;
5. Communicate effectively using visual, symbolic, and/or language skills in various modes;
6. Use science and technology effectively and critically showing responsibility towards environments and health of others;
7. Demonstrate an understanding of the world as a set of related systems by recognising that problem-solving contexts do not exist in isolation [(Department of Education 1997) p. 10].

The document also specifies what are the Developmental Outcomes, which are important to the full development of each individual, and to social and economic development at large. The Developmental Outcomes ought to be fulfilled by expecting learners to:

1. Reflect on and explore a variety of strategies to learn more effectively;
2. Participate as responsible citizens in the life of local, national, and global communities;

3. Be culturally and aesthetically sensitive across a range of social contexts;
4. Explore education and career opportunities;
5. Develop entrepreneurial opportunities.

South Africa's Curriculum 2005 also specifies the need to include all learners, despite their specific problems, as part of its vision of an inclusive education system. With respect to special education, all requirements and special needs were taken into account in the process of developing learning programme guidelines. Learners with learning disabilities or difficulties in dealing with problems using the basic functions of reading, spelling and calculations will be assessed with the use of alternative methods, in order to evaluate their true potential and level of knowledge [(Department of Education 1997) p. 7-8]. I will discuss more about the state of learners with special needs in South Africa later in the chapter.

Part of the nature of OBE is affording the learner flexibility to develop at his/her own pace within and across phases. Therefore multi-grade/multi-age grouping is one useful form of classroom organisation [(Department of Education 1997) p. 16-17]. Gifted learners will benefit from the individualistic nature of the OBE curriculum in the sense that each learner can work and progress at his/her own pace, and gifted learners will be able to accelerate through the curriculum [(Department of Education 1997) p. 8].

Eight Learning Areas were adopted by the new curriculum for General Education and Training (GET), and each of them is explained in detail as far as their purpose, features and scope, the learning outcomes, the content involved, assessment standards etc. are concerned (Department of Education 2002) p. 4-43].

In the next section I describe the outcomes and themes of the Natural Sciences Learning Area as published in the Revised National Curriculum Statement of 2002.

2.1.9.2 The Natural Sciences Learning Area in Curriculum 2005

The Natural Sciences Learning Area Statement (NSLAS) is in line with the Curriculum 2005 Critical Outcomes, and guides educators as to how to apply them in science teaching contexts. The Natural Sciences Learning Area Statement envisions a new teaching and learning era, which recognises that the South African population have a variety of learning styles and they hold culturally-influenced perspectives. According to NSLAS, learners should have access to science education, which is learner-centred and helps learners to understand scientific knowledge, as well as environmental and global issues (Department of Education 2002) p. 5].

As mentioned, the curriculum framework was influenced by the process-led approach and this is manifested throughout the document. The purposes of NSLAS are to promote the development of science process-skills, to encourage the application of science content-knowledge, and to enhance the relationship and responsibilities between science, society and environment [(Department of Education 2002) p. 4]. These purposes should be accomplished through an emphasis on three Learning Outcomes, which will be used in the context of four Content Areas.

The Revised National Curriculum Statement specifies three Specific Outcomes, which refer to the specification of what learners are able to do at the end of a learning experience in each learning area. This includes skills, knowledge and values, which form the demonstration of the achievement of an outcome or a set of outcomes (Department of Education 2002) p. 6]. The Learning Outcomes are:

1. Scientific Investigation: the learner will be able to act confidently on curiosity about natural phenomena, and to investigate relationships and solve problems in scientific technological and environmental contexts;
2. Constructing Science Knowledge: the learner will know and be able to interpret and apply scientific, technological and environmental knowledge;
3. Science, Society and Environment: the learner will be able to demonstrate an understanding of interrelationships between science technology, society and environment [(Department of Education 2002) p. 6].

Learning Outcomes 1, 2 and 3 are used to assess progress in the learner's ability to plan and carry out investigations involving knowledge [(Department of Education 2002) p. 7]. Assessment standards are attached to each Learning Outcome in general and specifically to each phase. The document also ties the Learning Outcomes to the Critical Outcomes, providing educators with a more holistic view of the curriculum.

There are four Content Areas around which the Learning Outcomes are taught:

- *Life and Living* focuses on life processes and healthy living, understanding balance and change in the environment and the importance of biodiversity;
- *Energy and Change* focuses on how energy is transferred in physical and biological systems and how human needs and uses influence resources;
- *Planet Earth and Beyond* focuses on the planet structure and change over time and the planet as a part of the universe;
- *Matter and Materials* focuses on the properties and uses of materials, their structure, changes and reactions.

A very detailed section concerning process-skills definition and application across the Learning Outcomes is given as well. In this section the document specifies the processes and skills which relate to the Natural Sciences, some of which were discussed earlier in this chapter. The document includes the following thinking skills and processes: observing and comparing, measuring, recording information, sorting and classifying, interpreting information, predicting, hypothesising, planning science investigations, concluding investigations, communicating science information, making inferences and formulating questions for investigation [(Department of Education 2002) p. 13-14].

I will now discuss issues regarding special education in general and in South Africa in particular, as well as issues concerning labelling, inclusion and human rights.

2.2 The Nature of Learners with Special Needs

Every learner is unique and requires special attention. Genetics, background, personal problems and circumstances affect and shape abilities to learn. Therefore the educational system must be sufficiently flexible and sensitive to be able to provide proper education to all learners, whatever their background or circumstances. Learners with special needs are also included here. Being exceptional implies that others are the "norm"; this in turn raises questions regarding what is considered "normal". In the next sections I discuss some the issues involved, such as labelling and classification of difficulties and disabilities in learning, the etiology of special needs generally and in the South African context specifically, and different systems to educate learners with special needs.

2.2.1 The Problem of Labelling

Observations and experiments led to the development of theories correlating certain physical and mental attributes and skills with specific ages. Developmental charts or scales are used to evaluate children's development, while IQ tests are the common way to evaluate intellectual abilities or intelligence [(Ashman and Elkins 1994) p. 6]. These references are a guideline to what is considered to be standard or normal development by society and therefore by psychologists, specialists, educators, etc. 'Being exceptional' refers to children who have skills either below the average or above it, and who therefore require a special type of education. In other words, 'learners with special needs' is a broad term used to describe learners who display a greater difference from the 'norm' than usual, and who therefore require special educational services in order to accommodate them in schools. Learners with special needs may display a wide range of symptoms, from having clear, obvious physical problems, to light problems which are even hard to diagnose such as a specific difficulty in learning.

It is part of human nature to classify and categorise much of what appears in the environment. There is no doubt that this is a useful skill to organise information into categories and label it for the purpose of generalisation, simplification and memory. However, dividing people into different groups can also be very problematic and have clear disadvantages [(Ashman and Elkins 1994) p. 6]. Classification involves the identification of some features that cause an individual or group of people to stand out from the general population. Classifying children may lead to their separation from regular classes, or providing them with better and proper education. Therefore, classification of learners with special needs and their diagnosis can be problematic and difficult, and may involve issues that are still contested today [(Ormrod 1995) p. 187].

Historically, the purpose of diagnosing and labelling learners was to exclude them from the general population, even though sometimes this ended up in their being placed in special education programmes designed specifically for them [(Ashman and Elkins 1994) p. 7]. In South Africa it is reported that 'educationists used to classify people with disabilities according to (their) disability, and that learners with disabilities were either placed in special schools or classes, or totally excluded from any educational opportunity on the grounds of that they were 'too severely disabled'' [(Republic of South Africa 1997) p. 37; (Republic of South Africa 2001) p. 2; (Engelbrecht 2004) p. 1].

The question of diagnosis is a complicated one and experts disagree about the definitions of some categories and which procedures to use in order to identify members of different categories. In addition, the interpretation of such assessments may lead to different conclusions and learners may belong to two different categories and require different kinds of assistance, or it might be that members of the same category act quite differently and are often more dissimilar than alike, which in turn requires very different kinds of support [(Ormrod 1995) p.187; (Ashman and Elkins 1994) p. 7]].

One of the clear disadvantages of labelling relates to problems of lack of confidence and of low self-esteem on the part of learners. Many learners with special needs suffer from low self-esteem due to their existing condition. The 'White Paper on Integrated National Disability Strategy' (Republic of South Africa 1997) reports that many children with disabilities born into families of poor socio-economic backgrounds grow up believing that their disabilities are an economic and a social curse, and a burden on their families, and perceive themselves as worthless [(Republic of South Africa 1997) p. 5]. Experiencing continuous failure either in social activities or in scholastic achievements can also lead to low self-esteem. However, low self-esteem and lack of confidence can develop as a result of being labelled. Labels may lead to stigmas and inappropriate social responses such as teasing, ridicule and rejection expressed by society, and shame, guilt and self-pity on the exceptional learner's side [(Ashman and Elkins 1994) p. 7]. Moreover, labels tend to stay with the person throughout his/her life, resulting in low expectations on the part of society, as well as low self-esteem in the individual [(Ashman and Elkins 1994) p. 7].

Another disadvantage of using labelling is that the child's disability or difficulty becomes a general label, which is too easily understood to be describing the child as a whole. People might describe the child as "abnormal" and miss the ways in which the child is like the other children and therefore "normal" [(Donald *et al.* 1997) p. 232-3]. In this regard, Vygotsky argued that imperfections are not subjectively perceived as "abnormality" until they are brought into the social context; they not only alter the child's relationship with the world, but above all affect his/her interaction with people [(Gindis 1995) p. 78]. From a slightly different angle, the unintentional massage of inferiority might be communicated to their peers by the labelling [(Ormrod 1995) p. 188].

On the other hand, there might be advantages to labelling and the classification of learning disabilities and difficulties. Learners in the same category have common problems, which might make it easier to identify and to assist them. It also allows social and political forces to promote the interests of those learners and help them by providing support to them and their families. Moreover, usually in Westernised countries federal funds are transferred only when learners with special needs are formally identified as having particular disabilities [(Ormrod 1995) p. 189]. In other words, without the labelling special education would be a lot harder to fund [(Ashman and Elkins 1994) p. 7]. In South Africa, however, disability grants (on average R350) were paid out to approximately 30% of the people with disabilities in 1993, while the majority of people with disabilities receive no grants at all [(Republic of South Africa 1997) p. 2].

In any case, people with disabilities themselves favour the official terminology used, because it is specific and can help in the process of getting public and political recognition of the special needs involved [Rieser and Mason in (Donald *et al.* 1997) p. 72].

The terminology that is used in this text is in line with recent United Nations and South African recommendations [(Republic of South Africa 1996) in (Donald *et al.* 1997)

p. 73]. A broad and major classification of the characteristics which learners with special needs display is given below.

2.2.2 The Etiology of Special Needs

The reasons for special needs, or the etiology of special needs, can be classified roughly into 4 categories: students with learning and performance difficulties, students with physical and sensory disabilities, gifted learners and learners at risk [(Ormrod 1995) p. 190].

Disabilities are conditions that have some clear physically identifiable basis. These include conditions such as physical and health impairments, sensory (e.g. visual and hearing) impairments, and neurological disabilities such as epilepsy and central nervous system dysfunction (Dawes and Donald 1994 p. 72; Ormrod 1995 p.189).

Difficulties in learning and performance consist of mild intellectual difficulties, speech and communication disorders, emotional and behavioural problems, and learning disabilities including Attention Deficit Hyperactive Disorder (ADHD). Difficulties in learning are less readily identifiable, do not always have a clear physical basis and are more subject to different interpretations in different social contexts (Dawes and Donald 1994 p. 72; Ormrod 1995 p.189).

Gifted learners are learners who display an unusually high ability in one or more areas, and also require special educational services to meet their special needs [(Ormrod 1995) p. 207].

At risk learners are learners who have a high probability of failing to achieve the minimum academic skills necessary for success in the adult world. This can be a result of impaired physical skills or lack of intellectual skills, or because of specific behaviour that can interfere with school progress [(Ormrod 1995) p. 212; (Ashman and Elkins 1994) p. 4].

Exceptionality can be seen as a result of problems within or internal to the learner; these will be referred to as "internal factors". They can be seen to be the result of severe social and educational disadvantages, which will be referred to as 'external factors' [(Donald *et al.* 1997) p. 69].

In Western countries 10% of the population have special needs, mainly due to internal factors as described above. However, in South Africa the estimation is that between 40-50% of the population could be in need of some form of special educational support due to internal or external factors, or a combination of the two [(Donald *et al.* 1997) p. 70]. This will be discussed in greater detail in the next section.

2.2.3 The Extent of Special Needs in South Africa

In order to understand the reasons for such a high estimate of learners with special needs, one needs to understand the specific etiology of learners with special needs in South Africa.

Engelbrecht claims that 'Apartheid policies have left a legacy of sever disparities with the result that learners of all ages find themselves in a society that struggling to meet the most fundamental needs of all its citizens' [(Engelbrecht 2004) p. 2]

First, people who are poor are more prone to health risks associated with malnutrition, diseases (such as tuberculosis, pneumonia and others) and infection, which might result in cognitive or sensory impairments [(Donald 1994) p. 138]. The White Paper on Integrated National Disability Strategy [White Paper on INDS] published by the South African government supports this notion by including *poverty* as one of the causes of disability, specifying that 'disabilities are caused or exacerbated by overcrowded and unhealthy living conditions. Disability feeds on poverty and poverty on disability' [(Republic of South Africa 1997) p. 8; (Engelbrecht 2004) p. 2].

Second, young children from low socio-economic communities are at higher risk of injuries, for example, as pedestrians, since parents are obliged to work and they cannot afford alternative child-minding facilities. Head injuries cause disabilities and difficulties in learning [(Donald 1994) p. 140]. The government report supports this notion, specifying that disabilities are caused by industrial, agricultural and transport-related accidents [(Republic of South Africa 1997) p. 8].

Third, the chances of permanent disabilities increase when access to health services and appropriate treatment is limited, as is the case in South Africa. For example, lack of awareness of risks to the unborn child during pregnancy, or lack of treatment for prenatal, peri-natal or post-natal complications [(Donald 1994) p. 141]. Lack of information, unhealthy lifestyle and failure of medical services are also mentioned as causes by the White Paper on INDS [(Republic of South Africa 1997) p. 8].

Fourth, lack of health screening to identify, for example, hearing and visual problems, lack of interventions, and the prevention of developing learning disability increase the cases of special education in poor communities [(Donald 1994) p. 141].

Fifth, being subjected to physical or sexual abuse, experiencing the distress of divorce, living with parental psychiatric illnesses or alcoholism, and being exposed to violence are general risks for all children. However, the risk of being exposed to them is higher in poor communities [(Engelbrecht 2004) p. 2; (Dawes and Donald 1994) p. 2]. Furthermore, conditions of violence in South Africa are amongst the highest in the world. For example, according to the government's 1992 figures, South Africa had 20,000 murders per year and 24,812 rapes were reported, which is estimated to be about 20% of the actual figures [(Dawes and Donald 1994) p. 5].

Last but not least, many children in South Africa drop out of school in order to help their families by working or raising siblings, or because parents cannot afford schooling [(Dawes and Donald 1994) p. 4]. Others become street children as a result of families' inability to provide proper support for the development of children [(Dawes and Donald 1994) p. 5].

In addition, due to the policies of apartheid, education in South Africa was the responsibility of 18 different and uncoordinated education departments, characterised by an unequal distribution of resources in education. This resulted in overcrowded classrooms, lack of teaching and learning materials, under-qualified teachers, excessively high pupil-teacher ratios, and lack of specialist and support services [(Engelbrecht 2004) p. 2; (Dawes and Donald 1994) p. 3]. These severe conditions led to high failure rates in the first two years of school and a consistent dropout rate from school. It was estimated that one fifth of the population over the age of 16 had never attended school and that basic literacy rates ranged from 50-60% of the population [*The Economist* 29 February 1992 in (Dawes and Donald 1994) p. 4].

Under these circumstances, the combined effect of internal and external factors has resulted in a much higher proportion of children with special needs. However, any attempt to gather more current and national representative information is bedevilled because of inconsistency and unreliability of reporting as well as by the variety of categories of special needs used by the different departments. As a result, there is no precise information on the actual percentage of learners with special needs in South Africa at that time (Donald *et al.* 1997) p. 230, (Donald 1994) p. 146].

I will now describe briefly some of the characteristics of learners with disabilities and difficulties.

2.2.4 Learners with Difficulties and Disabilities

Learners with difficulties and disabilities can be roughly divided into clear physically based disabilities, which will be referred to as physical and sensory disabilities, and less clear cases that lead to difficulties in learning. A short description of the different characteristics of learners' disabilities and difficulties follows below.

2.2.4.1 Physical and Sensory Disabilities

Physical and sensory disabilities include physical and health impairments, visual and hearing impairments, and neurological dysfunctions:

- Physical and health impairments are usually long-term conditions that interfere with school performance to such an extent that special instruction, curriculum, equipment or facilities are required. They can involve mobility disabilities as a result of diseases such as multiple sclerosis, muscular dystrophy, polio, etc., or chronic illnesses such as diabetes, cystic fibrosis, heart problems, arthritis, cancer and AIDS, or can be a result of a specific genetic background, an accident or developmental problems. However, learning abilities are usually similar to those of non-disabled learners [(Ormrod 1995) p. 201, (Donald *et al.* 1997) p. 256-7].
- Visual and hearing impairments: Visual disabilities range from total blindness through various degrees of loss of vision, whereas hearing disabilities range from impaired hearing to total deafness [(Ormrod 1995) p. 202-4, (Donald *et al.* 1997) p. 258].
- Neurological dysfunctions have to do with the physical functioning of the brain and the nervous system, which control movement and co-ordination. They can lead to a

variety of problems in speech, perception, hand-eye co-ordination and other associated problems. Diseases and early infections, injuries, congenital or developmental factors can be the cause of such problems [(Donald *et al.* 1997) p. 259].

2.2.4.2 Difficulties in Learning

Difficulties in learning consist of mild intellectual difficulties, learning disabilities, speech and communicational difficulties, and emotional and behavioural problems:

- Mild intellectual difficulties can be characterised as slow and delayed development of scholastic skills in general and sometimes delayed development of physical skills as well. Many learners with mild intellectual difficulties will be considerably older than other children at the same scholastic level and will be able to learn the skills expected, but this will take longer than in the case of other learners of the same age. The learners' level of cognitive skills such as writing, reading and spelling is likely to be limited and slow, their thinking is often concrete and they often act less maturely than expected [(Ormrod 1995) p. 191, (Donald *et al.* 1997) p. 280].
- Learning disabilities (LD) refers to a heterogeneous group of disorders manifested mainly by difficulties in mastery of one or more of scholastic skills such as listening, speaking, writing, reasoning and mathematical skills [(Rourke and Del-Dotto 1994) p. 90]. Learners' scholastic performance is significantly below what might be expected from their general intelligence. Their performance might be uneven across different learning areas and learners may display problems with specific aspects of learning. Sometimes the learning disability is related to other minor neurological dysfunctions such as problems in attention, impulsivity, poor hand-eye co-ordination, restlessness, weak perception memory, language problems, etc., which affect specific scholastic performance, including difficulties in reading, writing, spelling and working with numbers. LD can be a result of genetic background, neurological factors resulting from factors interfering with development, epilepsy, injuries or other causes, and can be aggravated if not identified early and supported accordingly [(Donald *et al.* 1997) p. 286].

Symptoms of Attention Deficit Hyperactive Disorder (ADHD) fall into this category as well and learners with ADHD present symptoms related to inattentiveness, hyperactivity-impulsivity, or a combination of both [(Conners and Jett 1999) p. 3-4].

Symptoms of inattentiveness include making careless mistakes, being distracted easily, and being forgetful and disorganised. Such learners might have difficulties listening to others, following instructions or completing tasks. Hyperactivity-impulsivity characteristics include restlessness and being fidgety, speaking out of turn and being impatient.

It is not clear whether ADHD is one disorder or a spectrum of disorders; however, learners may be considered as having ADHD disorder if they manifest six or more of either the inattention or hyperactivity-impulsivity symptoms for at least six months [(Conners and Jett 1999) p. 3-4].

- Speech and communicational difficulties are a group of problems interfering with academic performance mainly related to articulation, mispronunciation of sounds and words, stuttering and other language patterns, such as speaking too loudly or too softly. Speech difficulties may draw attention to the way one speaks rather to what one says. This in turn may cause stress to the speaker as well as to the listeners and interfere with communication [(Ormrod 1995) p. 197, (Donald *et al.* 1997) p. 282].
- Emotional difficulties and behavioural problems can have negative effects on classroom successes and achievements. These include problems in socialising with adults and peers, depression, dependence on others, aggressiveness and anti-social behaviour such as stealing and lying [(Ormrod 1995) p. 198, (Donald *et al.* 1997) p. 293-4].

Learners with these types of disabilities and difficulties, gifted learners and learners at risk require special services from the educational system, which is the focus of my next section.

2.2.5 Educating Learners with Special Needs

As the term implies, special needs are seen as exceptional compared to ordinary educational needs, and members of each of the categories require different resources and other solutions in order to be accommodated in ordinary schools. Therefore until quite recently children with special needs were educated in specialised institutes or self-contained classes. Along with their exclusion, their curricula were adapted to their abilities and specialised teachers taught them. It was widely believed that this type of education could help the special learners enhance their development and enable them to become part of society. However, some parents and educators argue that learners do not benefit from being excluded from the ordinary schools and that their academic achievements did not improve and sometimes even got worse in special schools. Moreover, they did not participate in the same activities as other learners nor did they have the same opportunities [(Ormrod 1995) p. 179].

As part of the development of human rights, it was widely accepted that children have the right to be seen and treated as normally as possible, whatever their disability or difficulty in learning. Therefore, the Individuals with Disabilities Educational Act (IDEA) was passed as a public law in the USA in 1975 and was re-authorised in 1997. Similar legislation was passed in the UK in 1993 and 1996.

In South Africa a White Paper on Integrated National Disability Strategy was published in November 1997, which deals with similar issues and will be described in more detail in the next section.

2.2.6 White Paper on Integrated National Disability Strategy

The South African government published a White Paper on Integrated National Disability Strategy [White Paper on INDS] in which the main message is 'Society for All' [(Department of Education 2002) p. v]. The White Paper includes analysis of the situation regarding disabled people and a policy guideline with recommendations about the ways to improve the situation of learners with disabilities in the future. Key policy areas have been identified including prevention, health care, rehabilitation, public education, barrier-free access, transport, communications, data collection and research, *education*, employment, human resource development, social welfare and community development, social security, housing, and sport and recreation. The White Paper has developed policy objectives, strategies and mechanisms to address each of these areas (*ibid.* p. v; my italics).

According to the White Paper, in a 1995 survey the Central Statistical Services reported a disability prevalence of approximately 5% in South Africa and mentioned that it affects families of disabled people as well as the immediate community (*ibid.* p. 1). The document specifies the reasons for people with disabilities as: violence and war, poverty, lack of information, failure of medical services, unhealthy lifestyle, environmental factors, accidents and social environment conditions, which deprive people with disabilities of prevention and treatment (*ibid.* p. 8). (Some of these issues were discussed earlier under 'The Extent of Learners with Special Needs').

Some sectors in the disabled community have suffered higher levels of discrimination and exclusion than others; among these are children and youths and in particular black children and youths. More than 80% of black children with disabilities live in poverty-stricken conditions, have poor access to appropriate health care, and are less likely to attend school, go on outings and experience situations requiring problem-solving or making a contribution to household chores. They are often excluded from their family, friends and peers, and so non-disabled children learn that the exclusion is the norm and also that this exclusion is acceptable in society. As a result they grow up as disempowered adults and are often unemployed (*ibid.* p. 5). Youths with disabilities, especially homeless youths, youths who have come into conflict with the justice system, and youths who did not have proper access to formal education experience similar difficulties (*ibid.* p. 7).

In line with human rights movements the White Paper emphasises that people with disabilities are equal citizens and should therefore enjoy equal rights and responsibilities. This in turn implies equal distribution of resources to ensure the same opportunities for all members of society, as well as building higher expectations of persons with disabilities (*ibid.* p. 10).

The White Paper argues that the circumstances of people with disabilities and the discrimination they are facing are created by society and have little to do with the impairments of the persons with disabilities. Therefore the "cure" to this "problem" lies in the reconstruction of society. In other words, it is the inability of the ordinary schools to deal with diversity in the classroom that forces children with disabilities into special schools (*ibid.* p. 11, quotation marks in original document). This argument is supported widely; for example, Elkins (1994) claims that 'in many cases the restriction is not an inevitable consequence but is socially imposed. If society decides that ramps, lifts, and special toilet facilities are necessary and appropriate in all public buildings, then wheelchair users are no longer handicapped in most daily activities' [(Ashman and Elkins 1994) p. 5]. The implication of these statements is an inclusion approach, in which persons with disabilities are included in society and have the same opportunities and obligations as other members of society.

The principles of the inclusion approach were included in the Constitution of South Africa in 1996, which guaranteed the prevention of discrimination against disabled people [(Republic of South Africa 1997) p. 17; (Engelbrecht 2004) p. 2; (Department of Education 2001) p. 2].

As a result, the policy guidelines in the White Paper on education specify the principle that 'all South Africans should have equal access to education opportunities, irrespective of the severity of their disability(ies)', and that 'respect for diversity of every member of the society should be promoted' [(Republic of South Africa 1997) p. 39; (Department of Education 2001) p. 2].

The White Paper proposes five objectives for the transformation of the education system as whole and lays down the principles for inclusive education:

1. To facilitate equal access to education - including community initiatives - and equity in education provision at all levels;
2. To develop a single education system that will cater for the needs of all learners within an inclusive environment with various placement options;
3. To facilitate capacity building for all stakeholders (parents, teachers, learners and planners);
4. To facilitate earlier access to education for all learners, but in particular for learners with special needs;
5. To facilitate effective and relevant research [(Republic of South Africa 1997) p. 38-9].

These are the principles that guide an inclusive education, which will be discussed a bit more in the next section.

2.2.7 The Inclusion Approach

The inclusion approach, leading to the educational policy of inclusive education, became an international trend towards the integration of learners with special needs into ordinary schools [(Ashman and Elkins 1994; Donald *et al.* 1997; Ormrod 1995)]. The inclusion approach is based on the basic rights of all learners to receive an education, and promotes access to and provision of education, which is appropriate to the needs of all children, whatever their original background or circumstances may be. This in turn promotes mainstreaming, which refers to the inclusion of children with special needs, wherever possible and practical, into the "normal" mainstream school, classroom and curriculum [(Donald *et al.* 1997) p. 20; (Engelbrecht 2004) p. 1]. Thus, inclusion is a concept which views children with disabilities as full-time participants and members of their neighbourhood schools and communities, not in a range of alternative placements but rather seeing that all learners are educated in the same physical location [(Knight 1999) p. 3]. However, in order to effectively educate all learners, whatever their situation is, specific arrangements and use of resources to support learners with special needs in those schools must be provided. For example, educational support services such as remedial teachers, occupational and speech therapists, educational psychologists, social and health workers, support classes and small group tuition [(Donald *et al.* 1997) p. 236; (Ashman and Elkins 1994) p. 17].

Due to administration problems during the apartheid era, in reality mainstreaming in South Africa occurred long ago; however, this was by default rather than by choice. Many of the learners with special needs went to local schools, since they did not have any other choice, and the facilities, resources and supporting specialists were not available to them, especially in the rural areas [(Donald *et al.* 1997) p. 237]. However, more severe cases of learners with special needs were excluded from the local school altogether.

Understanding the South African context in terms of what might be the answer to inclusive education and mainstreaming means accepting a gradual move towards mainstreaming, using placement alternatives, which can provide solutions by offering the help and sources required for learners with special needs [(Engelbrecht 2004) p. 3; (Donald *et al*. 1997) p. 238]. Children with special needs will gradually be absorbed into the mainstream schools, when those will have the capacity, resources and means to meet their needs, and the existing system of separate education would cater for more severe cases of disabilities and learning difficulties, which cannot be attained by mainstreaming [(Donald *et al*. 1997) p. 238].

The placement alternatives are:

- Mainstream classroom, with consultative support from the teacher support team (TST);
- Mainstream classroom, with consultative support from the TST and Education Support Services personnel (remedial teacher, educational psychologist, school health worker, etc.);
- Mainstream classroom, with periods when the learner is temporarily withdrawn for individual or group remedial assistance by a specialist (for example, a remedial teacher);
- Support class in a mainstream school. A group of learners with similar special needs who are taught for most of the day by a specialist teacher, but may join classes for non-academic subjects and extra-mural activities;
- Separate special schools or institutions. These cater for severe special needs in different categories of disability (for example, a school for the blind) [(Donald *et al*. 1997) p. 236; (Engelbrecht 2004) p. 3].

In the next few sections I will describe Feuerstein's perception of special education and special learners, as well as his theory, intervention programme and research, since Feuerstein developed an intervention programme to teach thinking skills and develop cognitive functions known to be suitable for learners with special needs.

2.3 Special Needs According to Feuerstein

Special education, as mentioned, involves individuals who require special services. One of the arguments described earlier is that the factors which cause some of the learners' difficulties and disabilities in learning can be internal, external or the interaction between the two. However traditionally, and as described until now, it is the individual's competence to learn that is impaired. A different point of view argues that the problem does not lie only in the individual's ability to learn, but rather with the ability of the teachers to teach [Dunn 1968, in (Feuerstein *et al.* 1981) p. 270]. Feuerstein (1981) suggests that it is examining the combined effect of the two arguments that may give a more suitable explanation, in that at least part of learning depends on the interaction between the learner and the teacher. It might be that the interaction itself is problematic and it will therefore be useful to distinguish between the learner and learning (or non-learning) and between the teacher and the curriculum (Feuerstein *et al.* 1981) p. 269-270]. Feuerstein elaborates by saying that it is the conditions that are special and the circumstances that are special rather than the 'special learner', and in a similar way it is the curriculum that is disabling, rather than the incompetence of the teacher to teach. Feuerstein suggests that 'What is required is a special kind of educational curriculum to satisfy the needs of a special kind of non-learning phenomenon' [(Feuerstein *et al.* 1981) p. 270]. Feuerstein developed a curriculum based on his theory of mediated learning experience (MLE), which will be discussed in the next few sections.

2.3.1 Culturally Different and Culturally Deprived

Reuven Feuerstein, an Israeli psychologist, developed a theory of learning that consists of two major concepts: structural cognitive modifiability and mediated learning experience (MLE), based on his observation of Jewish immigrant children in southern France between the years 1950-1961 [(Feuerstein and Feuerstein 1991) p. 4]. In order to explain these concepts some background is required. The learners he assessed displayed intellectual and academic dysfunctions when compared with learners in Geneva. Analysing the immigrants' performances based on Piagetian and other cognitive tasks, Feuerstein distinguished between 'culturally different' learners and 'culturally deprived' learners. Culturally different individuals were able to change and become modified, as Feuerstein describes it, through direct exposure to stimuli, and turn the direct exposure to stimuli into a source of new and more efficient strategies to learn. The 'culturally deprived' learners were unable to benefit from direct exposure to sources of stimuli and therefore were not able to learn [(Feuerstein and Feuerstein 1991) p. 4-5]. The term 'culturally deprived' learners describes learners who were for different reasons deprived of their own culture. Feuerstein discovered that the community he assessed, mainly a Moroccan community of Jews, were uprooted, scattered and fragmented; they became urbanised and poor, and lost or rejected the traditional values of their parents [(Fisher 1990) p. 131]. Irrespective of the reasons for the lack of transmission or mediation in the communities Feuerstein assessed, it resulted in lack of modifiability, rigidity and low level of adaptability of the individuals in the 'culturally deprived' group [(Feuerstein and Feuerstein 1991) p.4]. Feuerstein also assessed Ethiopians Jews, the Falashas, who came from the isolated highlands of Ethiopia. Children in this society had valued roles and were introduced from an early age to the rituals and cultural traditions of the community. They had to learn by heart passages from the bible and learned to read sitting in groups. Since there were not enough books, they learned to read from different angles (upside-down, left to right etc.!). Apparently the Ethiopian learners had some qualities that helped them to adapt very well into Israeli society [(Fisher 1990) p. 132]. Feuerstein argues that each and every culture contains all the social elements that are essential for adequate cognitive development, which are transmitted to children through a broad set of processes that he calls 'intergenerational cultural transfer' [in (Haywood 1993) p. 30]. Cultural experience provides a powerful means to interpret reality by passing on values, social rituals, traditions, stories and myths, and they in turn help the child to develop his information-processing capacities [(Fisher 1990) p. 132].

Based on his observations, Feuerstein developed a theory that explains the difference in modifiability of different populations. This is discussed in the next section.

2.3.2 The Mediated Learning Experience and Structural Cognitive Modifiability

Feuerstein's theory of mediated learning experience (MLE) explains the difference in modifiability between 'culturally deprived' and 'culturally different' learners. MLE is a theory of learning, where a teacher, a parent or other caregiver directs the child's attention to a particular object or situation, and assists him or her to interpret and gain meaning from the surrounding environment [(Feuerstein 1980) p.16]. The mediating 'agents', mainly adults significant in the child's life, guided by their own culture, intention and emotional investment, select and organise the world of stimuli for the child. By choosing the specific stimuli and introducing them to a child, while ignoring other stimuli, the child learns that the universe has a predictable structure and understanding this structure may help in future situations. The child learns that it is possible to explain phenomena and generalise events. He/She is encouraged to use rules that help to organise observations and test these rules in a variety of circumstances [(Fisher 1990) p. 133, (Haywood 1993) p. 27]. The cognitive structure of the child is affected and the child acquires behaviour patterns and learning sets, which in turn enable him/her to become an independent and autonomous learner who can be modified by a direct exposure to stimuli [(Feuerstein 1980) p. 16]. Feuerstein summarises these ideas:

> Whether a child learns to construct a canoe or a transistor radio, he/she must simultaneously learn to plan ahead, employ appropriate strategies, understand how the part relates to the whole, draw logical inferences and so on. Over and above the specific of any task or skill, whether writing a computer program or tracking an animal, information must be organised, operations performed, and an entire set of complex activities integrated into a purposeful and meaningful system of action. Thus, MLE may be understood as the transmission of universal cognitive structures by the initiated to the uninitiated and immature members of society. It is acquisition of structure that renders the individual adaptable or modifiable [(Feuerstein *et al.* 1981) p. 272].

MLE theory is different from previous theories that explain cognitive development. For example, the behaviourist approach describes conditioning in a stimuli-response (SR) manner, in which a direct exposure to stimuli produces a change. MLE also differs from Piaget's theory of 'stimulus, organism, response' (SOR), which regards the organism, its level of maturation and its stage of development, as playing important roles in registering and active elaboration of stimuli, as was described earlier in the chapter about Piaget's theory.

Feuerstein acknowledges the differences between individuals and their capacities to modify themselves, their cognitive structure, their knowledge base and their operational functioning following direct exposure to stimuli. He argues that some learners will be able to benefit and change after one exposure to stimuli, and will be able to generalise and effectively use the knowledge in other situations. Other learners, however, will need repeated exposure to stimuli and may use the knowledge only in the same situation [(Feuerstein and Feuerstein 1991) p. 10]. Yet, there are many individuals who would not be affected by repeated stimuli at all. In Feuerstein's view, cognitive developments do not only depend on learner maturity and stage of development, as Piaget argues, but are rather a combined result of interaction with the world and cultural transmission. He emphasises the importance of a human mediator between the world stimuli and the child that helps him/her gain meaning out of the world [(Feuerstein *et al.* 1981) p. 271; (Feuerstein and Feuerstein 1991) p. 13].

Thus, Feuerstein suggests that there are two ways to learn basic cognitive processes: through direct exposure to stimuli, without mediation, when children encounter events throughout their lives, or as Piaget described it, by assimilation and accommodation of new schemas; and through mediated learning experience, given by adults that interpret the event for children and help them gain meaning from these events [(Feuerstein *et al.* 1981) p. 271]. In Feuerstein's view, the more intelligent learners will need fewer exposures to stimuli and less MLE, whereas the less intelligent learners will need more MLE and repeated exposure [(Haywood 1993) p. 29].

Thus, structural cognitive modifiability can be defined as a belief that human beings have a dynamic system that enables them to modify their cognitive functions either by direct exposure to stimuli, as Piaget suggests, or by MLE through a human mediator. Therefore, MLE plays a major role in the ability of humans to adapt to their environment by learning [(Haywood 1987) p. 27; (Head and O'Neill 1999) p. 123].

Concerning learners with special needs, Feuerstein claims that the question is not whether they are capable of learning the basic skills, but rather how much MLE, and for how long they will need it, in order to do so [in (Haywood 1993) p. 27]. Therefore the state of these learners is a reversible one that depends mainly on the quality of MLE and readiness of the mediator to invest in order to change it [(Feuerstein and Feuerstein 1991) p. 271].

2.3.4 Etiological Conditions and Inadequate Cognitive Development

The various conditions that were regarded traditionally as the 'causes' of inadequate cognitive development – either with a genetic or congenital nature such as neurological impairments or other physical disability, or environmental conditions such as poverty, low educational level of parents and of class – are referred to by Feuerstein as 'distal etiological conditions' [(Feuerstein *et al.* 1981) p. 272; (Haywood 1993) p. 27]. Feuerstein argues that these conditions correlate with low performance; however, they are not the cause of the conditions. He claims that the direct and immediate cause is lack of MLE. This view is consistent with that of Vygotsky [(Gindis 1995) p. 79], which I will turn to later in the chapter. The genetic and congenital conditions may make the learner less receptive to MLE, while the environmental conditions and emotional disturbances may result in the mediator providing less MLE. Feuerstein also claims that, despite specific distal etiological conditions, adequate cognitive development can still occur, while low performance can occur in the absence of any distal conditions or in favourable conditions [(Haywood 1993) p. 28].

Haywood (1993) demonstrates this argument using poverty as an example, based on research data he published elsewhere (Haywood and Stedman, 1969). Haywood claims that it is true that 80% of the mildly mentally retarded children come from 'poor' families, but only 10% of all children coming from poor families are ever identified as mentally retarded. In the other 90% of families that have low economic conditions, children have normal intellectual functioning; thus it is clear that poverty does not cause mental retardation. Nevertheless, the percentage of mentally retarded children is three times more than what is found in the population, suggesting that the social circumstances of poverty and insecurity may contain some elements that enhance the correlation with mental retardation. Feuerstein argues that the main element that should be held responsible for this correlation is insufficient MLE, which is less likely to be provided under such conditions [(Haywood 1993) p. 28]. According to Feuerstein, since the proximal cause for inadequate cognitive development is lack of MLE, the deficits can be overcome by providing MLE in a systematic, intentional and focused intervention, even at later stages [(Feuerstein *et al.* 1981) p. 271].

The quality of MLE depends very much on the mediator's competence to mediate. But what is a good mediator and what are the mediation modalities?

2.3.5 The Mediator

MLE requires the use of a specific mediational teaching style and training, because it takes a long time. Ultimately practice and training enhance the teacher's capacity to think creatively, critically and metacognitively, so as to become a better mediator. Haywood (1993) describes Feuerstein's work in his article on a 'mediational teaching style' and also elaborates on the characteristics of good mediators. Haywood explains that mediators select stimuli for their learners and repeat exposure to them. They focus on relevant aspects of the stimuli, while reducing the complexity. They ask questions rather than give the answers and request justifications on right and wrong answers. They incorporate 'How' questions that encourage metacognitive thinking. Mediators bridge induction of rules by linking similarities in different events, and deduction by applying those same rules on various situations. In so doing they mediate predictability and order. They encourage learners to test the rules and revise them when they are not working [(Haywood 1993) p. 31-2]. Mediators mediate the intention of learning, its meaning and relevance [(Haywood 1993) p. 36]. By doing so, mediators satisfy some of the eleven MLE criteria Feuerstein identified, which should be present in order for the interaction to be meaningful [(Feuerstein and Feuerstein 1991) p.13]. Here is a short description of the twelve criteria of meaningful MLE:

1. Mediating 'Intentionality and Reciprocity' involves a desire to teach or mediate on the teachers' part, and receptiveness to learn on the learners ' part. Unless the interaction is interesting and inspiring for both sides, learning can hardly occur (from Instrumental Enrichment training course materials). The interaction

animated by an intention and an effort to create a relationship of reciprocity can be viewed as the main condition of MLE [(Feuerstein and Feuerstein 1991) p. 17].

2. Mediating 'Meaning' involves providing the aims of a lesson, the reasons for doing a particular activity or learning about specific subject matter, because it is important for learners to know why they are doing it (from Instrumental Enrichment training course materials). This answers the questions of why, what for, where, how, by whom, how much, etc. [(Feuerstein and Feuerstein 1991) p. 24].
3. Mediating 'Transcendence' means applying and bridging (that is transferring) concepts to a broader context by relating to previous and future events and applying them to different situations (from Instrumental Enrichment training course materials). Transcendence means going beyond the goals of the interaction; it is the orientation of the mediator to widen the interaction to other situations in life [(Feuerstein and Feuerstein 1991) p. 20-21].
4. Mediating the feeling of 'Competence' means encouraging the learners to believe in themselves and to develop a positive feeling of success (from Instrumental Enrichment training course materials). It is developing an awareness and consciousness, through human mediation, of one's competence [(Feuerstein and Feuerstein 1991) p. 29].
5. Mediating 'Self-Regulation and Control of Behaviour' develops the ability of the individual to control his/her impulsive behaviour by increasing the awareness of the appropriateness of certain behaviours, their timing and suitability to the particular situation and so on [(Feuerstein and Feuerstein 1991) p. 37].
6. Mediating 'Sharing Behaviour' reflects the abilities of the individual to interact and participate with others and make others participate with him or her [(Feuerstein and Feuerstein 1991) p. 40].
7. Mediating 'Goal Planning' helps the learner to consider the environment as a predictable factor, which allows planning ahead with the security that such plans can indeed be implemented [(Feuerstein and Feuerstein 1991) p. 44].

8. Mediating 'Self-Change' means becoming aware of the self-change that can happen through learning and metacognition [(Feuerstein and Feuerstein 1991) p. 46-7].
9. Mediating 'Challenge' means mediating a comfortable feeling with regard to a change of state from the known to the unknown, which is a vital requirement in a changing world [(Feuerstein and Feuerstein 1991) p. 45].
10. Mediating 'Individuation' represent the need of the individual to become an articulate, differentiated self [(Feuerstein and Feuerstein 1991) p. 42].
11. Mediating 'Feeling of Belonging' is of particular importance at a time when the nuclear family offers little security to the child with regard to the stability of the framework within which the individual belongs [(Feuerstein and Feuerstein 1991) p. 49].
12. Mediating a search for optimistic alternatives entails making the child adhere to optimistic alternatives by anticipating positive outcomes [(Feuerstein and Feuerstein 1991) p. 48].

Based on his theory, Feuerstein developed an intervention programme called Instrumental Enrichment, by which cognitive functions can be developed. Instrumental Enrichment will be described in the next section.

2.3.6 Instrumental Enrichment

In order to redevelop the basic cognitive functions and improve the overall cognitive performance that focuses on the process of learning rather than on specific skills and subject matter, Feuerstein developed 14 instruments directed to teach specific cognitive functions explicitly [(Costa 2004) p. 9]. Feuerstein recognised and divided cognitive dysfunctions into three phases: problems in the *Input* phase interfering with the child's capacity to gather information and organise it. Problems in the *Elaboration* phase interfere with processing the information, relating it to previous knowledge, drawing relationships, reason, etc., and problems in the *Output* phase interfere with the ability to communicate their thoughts and share ideas in a meaningful way [(Fisher 1990) p. 141-142]. Each instrument focuses on a particular or a small set of dysfunctions and it is built up in a progressive way, divided into units, enabling the mediator to address a specific cognitive dysfunction using different pages in the instrument [(Feuerstein *et al.* 1981) p. 274]. Some of the instruments, however, specialise on specific skills and the implicit sub-skills they require like *comparisons* and *categorization* which may help learners improve their ability to master these skills [(Feuerstein *et al.* 1981) p. 163-175].

The tasks are content free and Feuerstein claims that, if learners had a negative experience with traditional academic tasks, they will enjoy the change of working with materials using a different approach and that any content serves as the vehicle towards understanding a concept [(Vye and Bransford 1981) p. 27]. If the concept or function was internalised, the content can change according to the context in which the function has been applied. The major goal of the programme is to enhance the cognitive modifiability of the individual by correction of deficient cognitive functions. That is done by teaching specific concepts, operations and vocabulary required by the different IE instruments and by consolidation of operational thinking and spontaneous use of them. Furthermore, the goals are to help learners develop metacognitive thinking and intrinsic motivation, and empowering the learner to become an active independent learner [(Feuerstein *et al.* 1981) p. 274-5]. The programme consists of the following sets of instruments: Organisation of Dots, Analytic Perception, Orientation in Space I and II, Comparisons, Categorisation, Instructions, Family Relations, Illustrations, Numerical Progression, Temporal Relations, Stencil Design, Transitive Relation and Syllogism. It is proposed that these instruments should be integrated into the regular school curriculum for 2-3 periods a week over 2 to 3 years [(Hobbs 1980) p. 568].

2.3.7 Empirical Support of the Effectiveness of Instrumental Enrichment

Feuerstein and his colleagues conducted research to evaluate the effectiveness of Instrumental Enrichment not only on a short-term basis but also over the long term. The original research was conducted in Israel on a total sample of 218 retarded adolescents between the ages 12 and 15 years [(Feuerstein *et al.* 1981) p. 281]. Results of pre-IQ tests indicated that the learners ranged from borderline to educable mentally retarded, and their general level of scholastic achievement was about 3 to 4 years behind their school peers.

After two years of intervention, the IE groups performed significantly better than the comparison groups on a few of the achievements tests and the pre-test differences in favour of the comparison groups were eliminated. Moreover, in a follow-up study approximately two years later, after the IE group were drafted into the Israeli Army, scores in the Army intelligence test 'DAPAR' placed the IE group within the normal IQ range and consequently they were eligible for opportunities that are closed to low-functioning individuals [(Feuerstein *et al.* 1981) p. 287].

Another study was designed to examine the effectiveness of Feuerstein's IE programme. It was conducted in North America in 1982 and served as a full systematic replication of Feuerstein's work. After 6 month of teachers' training and one year of implementation, the results from pre-tests and post-tests showed a clear indication of improved cognitive performance in IE class learners when compared with appropriate controls [(Narrol *et al.* 1982) p. 110].

A small-scale pilot study was conducted in Chicago in 1984 to evaluate the Instrumental Enrichment programme as an approach to enhance performance of learning disability (LD) adolescents (Messerer *et al.* 1984). The programme included one compound (Organisation of Dots) of Feuerstein's remedial instruments in IE, and was administrated over 15 lessons to four post-secondary students. Results from Feuerstein's pre- and post-programme evaluation, although very preliminary, indicate improvement in problem-solving strategies, suggesting that the programme had a profound impact on the learners [(Messerer *et al.* 1984) p. 322].

A large-scale study conducted by Ruth Arbitman and Carl Haywood (1980) in the United States of America and Canada evaluated the effectiveness of IE on learners with various categories of special needs like LD, 'Educable Mentally retarded', learners with behavioural disorders and disadvantaged learners. The intervention programme was administered for two years and results from IQ, motivational and scholastic achievement tests after one year were presented. They found no effect on school achievement after the first year of intervention; however, there were some indications of change in some intellectual functioning [(Arbitman-Smith and Haywood 1980) p. 56]. There were significant increases at the level of mean IQs of all IE learners compared with non-IE groups. Their study suggests that with appropriate mediation specific cognitive deficiencies of LD learners can be remedied. Participant learners showed an interest and motivation to learn and most teachers and parents reported a positive change in the behaviour of these learners [(Arbitman-Smith and Haywood 1980) p. 59-60].

A comparative evaluation of three 'thinking skills' programmes (Vye and Bransford 1981) described IE as a programme that helps learners become aware of the thinking processes that they use when they solve problems. It encourages them to analyse strategies and alternatives, and evaluate them as such. The IE programme, as described by the authors, is suitable for 'adolescents and pre-adolescents labelled retarded, learning disabled and so forth, although it is also used with normal and even gifted students since the latter are frequently unaware of their own implicit thoughts and processes' [(Vye and Bransford 1981) p. 27].

Sternberg and Bhana in their evaluation article (1986) describe the IE programme as 'especially suitable for special, including retarded and learning-disabled as well as normal populations'. They also noted that gains could be attained on standard kinds of IQ and aptitude measures, while the greatest gains are likely to be in the areas of abstract reasoning and spatial visualisation [(Sternberg and Bhana 1986) p. 63].

Vygotsky also described lack of mediation as a cause of cognitive dysfunctions. Vygotsky's ideas about mediation and related ideas will be discussed in the next section.

2.3.8 Vygotsky, Mediation and the Zone of Proximal Development

Vygotsky, a Jewish psychologist and an educator living in Russia between the years 1896-1934, developed one of the most important theories in developmental psychology, with mediation as it's major concept [(Kozulin and Presseisen 1995) p. 67]. Although chronologically he published his theory before Feuerstein did, his work was revealed to the West only in the late 1960s.

According to Vygotsky, all higher mental processes are mediated through language, signs and symbols through the social interactions between people, mainly by adults to children and between peers, which will later on be carried out independently by the learner [(Wells 1999) p. 6, (Blanck 1990) p. 46; (Kozulin and Presseisen 1995) p. 68]. Vygotsky thought that the interactions between adults and children are the key to learning and culture transmission, and this should be done by collaboration and direction, 'through demonstration, leading questions and by introducing the initial elements of the task solution' [Vygotsky, 1987, p. 209 in (Moll 1990) p. 11]. The way that children interact with others while solving problems, in turn, determines the intellectual skills they acquire. The learners internalise the help and guidance they receive from others and use them to guide their own thinking when solving other tasks (Kozulin and Presseisen 1995) p. 68].

Karpov and Haywood (1998), analysing Vygotsky work, define two types of mediation: metacognitive mediation and cognitive mediation. Metacognitive mediation refers to self-regulation processes such as self-planning, monitoring, self-checking and self-evaluating. Cognitive mediation refers to the tools that are necessary to solve problems. Vygotsky believed that children should not and cannot study the world through the approach of re-discovery, but rather scientific concepts should be transmitted ready-made [(Karpov and Haywood 1998) p. 27-8; (Kozulin and Presseisen 1995) p. 68].

Another major concept that Vygotsky developed is the zone of proximal development (ZPD), which he defined as the distance between the real level of development and the potential level of development [(Blanck 1990) p. 50]. It is the space that lies just beyond a child's present understanding, in which the child cannot quite understand something on his/her own, but has the potential to do so through interaction with another. The other person engages the child in thinking forward into that space, acts as mediator in shifting the child's present understanding to a new level [(Donald *et al.* 1997) p. 48; (Gindis 1995) p. 80]. Working in the zone means recognising the ZPD bounds by assessing and establishing the level of difficulty, offering a challenging task but not too difficult, followed by providing guided practice by an adult or a more capable peer. The more advanced partner or adult changes the degree and quality of support provided to the child, as he or she becomes more proficient. The predicted outcome is an independent performance by the child [(Moll 1990) p. 7].

Vygotsky placed a special emphasis on learners with learning difficulties and was the first director of the Research Institute of Defectology, which was later renamed the Scientific Research Institute of Corrective Pedagogy, in Moscow [(Gindis 1995) p. 77; (Blanck 1990) p. 41]. Vygotsky also believed that learners with special needs not only suffer from their own natural problem, but their impairments also affect their interaction with people. He wrote that 'organic impairments prevent handicapped children from mastering some or most of the social skills, and from acquiring knowledge at a proper rate.... Progressive divergency in social and natural development leads to social deprivation, as a society's response to a child's organic impairment... leads to delays in development ' [(Gindis 1995) p. 79]. According to Vygotsky, the way to rehabilitate learners with special needs is mainly to develop the cultural processes of abstract reasoning, logical memory, voluntary attention, etc., which will enable them to interact properly with society and adapt to it [(Gindis 1995) p. 79].

With respect to inclusion, Vygotsky made some statements that contradict each other. On the one hand, Vygotsky thought that learners with learning difficulties will benefit from peer learning, which might promote the development of cognitive functions, social interaction and self-esteem [(Watson 2000); (Gindis 1995) p. 79]. On the other hand, Vygotsky was convinced that only a special system could develop the cognitive functions that will allow learners with special needs to fully adapt to society [(Gindis 1995) p.79].

Based on Vygotsky's theory and Feuerstein's theory, the mediated learning approaches were developed world-wide and will also be applied to my own research.

2.4 Chapter Summary

The ability to think and solve problems effectively was regarded as genetically determined without the possibility to change or improve. I reviewed the research literature that evaluated intervention programmes aimed at teaching thinking skills and processes explicitly or implicitly to learners with a wide range of abilities. In this chapter I highlighted some of the reasons for the content-led approach withdraw in science instruction, which was based on teaching content knowledge and was aimed mainly at preparing learners for higher education. This approach was found to be not relevant to learners with average and below average abilities. Gradually, some of the most influential theories regarding cognitive development (Piaget) and science instruction (such as the *Discovery Approach*) developed and led to the rise of a new approach - the process-led approach. The process-led approach places an emphasis on thinking skills and processes, which were regarded as transferable between learning areas, and as being more accessible to a wider range of learners' abilities. Intervention programmes to teach thinking skills and processes started to emerge as a result of this pedagogical change.

Teaching thinking skills and processes can be infused into the regular curriculum or can form part of an independent intervention programme. In general, research data show that learners can learn and improve in problem solving and decision making, and can improve their scholastic performance by using thinking skills and processes as well as gaining content knowledge.

In addition, I discussed Curriculum 2005, which was implemented recently as part of the outcomes-based education system of South Africa. The Revised National Curriculum Statement (2002) emphasises the teaching of thinking skills, and adopted some of the principles of the process-led approach. According to the Natural Sciences Learning Area in Curriculum 2005, learners are expected to master a number of skills and processes as well as specific scientific content knowledge by the time they exit the educational system.

I discussed South Africa's policy regarding learners with special needs, which is based on an inclusive education. The inclusion policy implies mainstreaming all learners, including learners with special needs, and providing all learners with an education that will meet their needs, whatever these might be. I referred to the advantages and disadvantages of labelling and classifying learners with special needs as well some of South Africa contextual etiology, which led to such a high percentage of learners with special needs in South Africa.

I introduced Feuerstein's theory of mediated learning experience (MLE) and cognitive modifiability, and Vygotsky's theory of mediation and the zone of proximal development as ways to address the education to learners with special needs. I also discussed some of the principles of Feuerstein's intervention programme, instrumental enrichment (IE), as a way to teach thinking skills and processes explicitly and explained mediational aspects and what type of teaching style it requires.

In the next chapter I am going to present the research methodology of the study I conducted. It will identify different paradigms of social research, which are based on different assumptions regarding ontology, epistemology and methodology. Furthermore, I will discuss the principles of action research as a way to evaluate educational intervention programmes. I will also describe the research project in terms of its purpose and context, and explain the methods I have used to produce data over two cycles of inquiry. Lastly, I will describe triangulation and trustworthiness by which I tried to increase the validity of the research, as well as some ethical issues regarding the study.

Chapter Three

Research Methodology

3.1 Introduction

This chapter deals with the research methodology that underlies this project. First, the main paradigms of social science research will be identified and discussed. Special emphasis is placed on research coherence and the use of a research design as a way to achieve this coherence. Second, I will justify why I chose to work within the critical-emancipatory paradigm, carrying out evaluative action research to evaluate the intervention programme I have designed and implemented. I will further discuss the methods employed for data production and the steps that were applied to analyse them. Third, I will explain what efforts I undertook to increase the validity, credibility and dependability of the findings by employing multi-method triangulation and exploring the teacher's, the observer's and the learners' points of view. Finally, I will discuss some relevant ethical issues and I will describe how I negotiated access to the school where the research took place.

3.2 Social Science Research

Research concerns systematic inquiry that is characterised by principles, guidelines and procedures and generally subject to evaluation in terms of criteria such as validity, reliability and representativeness [(Hitchcock and Hughes 1995) p. 5]. According to Durrheim (1999), research consists of four stages: defining research questions, formulating a research design, research implementation, and writing the research report [(Durrheim 1999) p. 29-30].

Social science research can be framed within different research paradigms, each based on different assumptions regarding three dimensions: ontology, epistemology and methodology. Ontology relates to, or is, the study of the nature of existence (Franklin

Dictionary), and specifies the nature of the reality that is to be studied [(Terre-Blanche and Durrheim 1999) p. 6]. Epistemology is the study of the nature and limits of knowledge (Franklin Dictionary), and it describes the nature of the relationship between the researcher (knower) and what can be known [(Terre-Blanche and Durrheim 1999) p. 6]. Methodology has to do with the ideas, concepts, theories and frameworks entailed in the use of various methods or techniques employed to generate data on the social world. It determines the way that research should be operated, and specifies how the researcher may practically study whatever he/she believes might be known [(Hitchcock and Hughes 1995) p. 20; (Terre-Blanche and Durrheim 1999) p. 6].

In each of the paradigms different methods are used and various types of data are produced. However, it is important that there should be internal consistency among the aspects of the research and that these are broadly aligned within one paradigm and consequently that the research is methodologically coherent. Research design is one way to achieve coherence, which is the aspect I discuss in the next section.

3.3 Research Design

The research design is the planning phase of any research and serves as a framework for the research activity. Research design serves as a guide for researchers to determine what to look for and which techniques they might use in data production and analysis processes. It also helps the researcher to make sure that the study fulfils particular purposes and that the research is completed within the scope of the available resources [(Hitchcock and Hughes 1995) p. 79; (Durrheim 1999) p. 30].

According to Durrheim (1999), a research design has four components: the purpose of the research, the research paradigm, the context of the research and the research techniques employed [(Durrheim 1999) p. 33]. A coherent research design is achieved when the research purposes and techniques are organised logically within the research framework provided by a particular paradigm [(Durrheim 1999) p. 35]. Each of these four aspects will be discussed in the sections that follow.

3.3.1 The Purpose of the Study

The purpose of the study defines the questions of the research, the issues related to these questions, who or what is the research about, and what type of conclusions can be drawn from the research [(Durrheim 1999) p. 37].

When I came to South Africa I was uncertain about my abilities as a science teacher, especially with respect to learners with special needs, who are often confronted with difficulties in fulfilling their potential to develop their own thinking skills and to apply them in science disciplines. Questions regarding these issues guided my pedagogical interests and I started to inquire what has been done in this field and what can be done to develop it further, through a continuous process of asking questions, discussions with colleagues and supervisors, and by reading. I developed a better understanding of the field after I familiarised myself with Feuerstein's and Vygotsky's theories, as well as those produced by others and ascertaining in which ways these are applicable to me as a science teacher-researcher.

My interest was in offering some help to empower learners to become more independent, providing them with tools to become better learners and better thinkers, and to enable them to take decisions within their own in scientific contexts and in more general contexts. I was motivated by the belief that any person should be able to fulfil his/her potential, and that reasoning, thinking and problem solving as well as developing individuality is the only way to do so.

On the basis of these convictions I defined the purpose of my study as follows: to critically explore whether and to what extent teaching science using selected IE instruments can:

1. Contribute to the development of science thinking skills in learners with special needs?
2. Contribute to the transfer of thinking skills to other disciplines?
3. Provide the learners with an interactive science programme that is suitable for their special needs?
4. Increase student engagement in the science classroom, which is known to be of a benefit to learners with special needs? [(Bell 2002) p. 157].

5. Positively influence the classroom-learning environment, by providing learning experiences which can increase intrinsic motivation and associate science and learning in general with positive, fun experiences?

3.3.2 Paradigms in Social Sciences

Paradigms act as perspectives that provide a rationale for research and guide the researcher in using particular methods of data collection, observation and interpretation [(Babbie and Mouton 2001) p. 48-49; (Durrheim 1999) p. 36]. According to Terre-Blanche and Durrheim (1999), there are three major paradigms in social sciences, namely, positivist, interpretive and constructionist paradigms, which I now will describe briefly.

In the positivist paradigm reality is stable, external and law-like, and the researcher is an objective detached observer [(Terre-Blanche and Durrheim 1999) p. 6], whose aim is to explain people's actions, which he/she believes are reliably predictable under certain circumstances [(Kemmis 1990) p. 59]. Researchers working within this paradigm adopt the methods and procedures of the natural or physical sciences, using mainly quantitative ways of measurement and either statistical or experimental controls [(Babbie and Mouton 2001) p. 49; (Hitchcock and Hughes 1995) p. 22].

In the interpretive paradigm reality is subjective and based on people's experiences, and the researcher aims to understand people's subjective reasons and the meaning behind their actions [(Terre-Blanche and Durrheim 1999) p. 6; (Kemmis 1990) p. 59]. Studying human actions from the inside perspective is done through methods such as interviewing and participant observation that rely on developing a subjective relationship between the subject and the researcher [(Babbie and Mouton 2001) p. 53; (Terre-Blanche and Durrheim 1999) p. 6].

In the constructionist or the critical-emancipatory paradigm, reality is socially constructed [(Terre-Blanche and Durrheim 1999) p. 6], and the researcher aims to develop or improve people's actions, understanding and situations through collaborative action. The researcher is thus action oriented, working to change the world and transform the social order [(Babbie and Mouton 2001) p. 59; (Potter 1999) p. 219]. According to

Kemmis (1990), behind the research there is an interest in emancipating people from the constraints of irrationality, injustice, oppression and suffering, and developing their sense that they can act together to challenge and to change [(Kemmis 1990) p. 60].

Since my research is concerned with empowering learners by helping them to acquire the tools to enhance self-fulfilment – and also because of my interest in growing personally as a teacher-researcher – my research is broadly framed within the critical-emancipatory paradigm. Moreover, I was interested in being involved directly by improving my practice through the application of theories related to the teaching of thinking skills. Therefore, I characterise my work as applied research and specifically as programme evaluation, which I discuss now.

3.3.3 Applied Research and Programme Evaluation

In applied research the intention is to improve practice by directly involving those within the educational process in reflecting upon, evaluating and perhaps changing their practice [(Hitchcock and Hughes 1995) p. 102]. Applied research as opposed to basic or pure research must have practical applications, and aims to contribute towards practical issues of problem solving, decision making, policy analysis and community development [(Hitchcock and Hughes 1995) p. 6; (Durrheim 1999) p. 41]. Generally, applied research manifests itself in the form of planned social intervention, or as an action taken within a social context for the purpose of producing some intended result [(Babbie and Mouton 1995) p. 338-9].

Programme evaluation research refers to the research purpose rather than a research approach, and serves as a form of applied research. Programme evaluation research is about establishing whether social programmes are needed, effective and likely to be used, and the most commonly evaluated are programmes aimed at educational or social development [(Potter 1999) p. 209]. The central goal of programme evaluation is focused on answering practical questions regarding the outcomes and implementation as well as on the quality of service provided [(Potter 1999) p. 210]. Unfortunately in many programme evaluations, evaluation reports are prepared as part of the end-point of the research and these tend to have a short half-life and are even forgotten or ignored

[(Babbie and Mouton 1995) p. 338; (Hopkins 1993) p. 192-193]. However, programme evaluation can provide important perspectives, leading to practice change and implementation changes, and may bring the best practice into the classroom, by the involvement of teachers in decision making in the day-to-day life of a school (Hopkins 1993) p. 192-193]. For this research I designed an intervention programme to teach thinking skills in science to learners with special needs. I intended to track the effectiveness of this programme in terms of learners' progress, practice change and my personal growth as a science teacher.

Since applied research could be based on any of the mentioned paradigms, data can therefore be produced qualitatively and quantitatively [(Hitchcock and Hughes 1995) p. 31]. Positivist evaluation research is based on the belief that the scope of programme evaluation is limited to those aspects, which can be objectively observed and tested [(Potter 1999) p. 211]. Interpretive evaluation is based on participant observation, case studies, qualitative interviewing and analysis, and multi-method approaches involving triangulation between different investigators, methodologies, data sources, etc. [(Potter 1999) p. 214-215].

There are a number of different critical approaches to programme evaluation research, which vary in the degree to which the evaluator becomes directly and practically involved in the programme's development, and the degree to which the evaluator's own ideology and social activism influence the programme's participants [(Potter 1999) p. 219-220]. Critical-emancipatory approaches to evaluation are usually based on a small-scale evaluation or case study, with the usage of action research. This approach will be discussed in the next section.

3.3.4 Action Research and Participatory Action Research

Action research and applied research are similar in the sense that both utilise the scientific method by identifying problems, formulating a hypothesis, planning data collection and analysing results. However, according to Halsey (1972), action research is a small-scale intervention in the functioning of the real world, and a close examination of the effects of such intervention [in (Cohen and Manion 1994) p. 186]. According to

Rapoport (1970), it is a special type of applied research, which involves participants experiencing problems directly in the search for a solution [in (McKernan 1991) p. 4; (Babbie and Mouton 2001) p. 64, 67]. Carr and Kemmis defined action-research as a 'form of collective self-reflective enquiry undertaken by participants in social situations in order to improve the rationality and justice of their own social or educational practices, as well as understanding of the situations in which these practices are carried out' [(Altrichter *et al.* 1990) p. 3].

Action research is a cyclic process involving stages of action, observation, reflection and analysis, re-planning the action and acting again. Action research models are based on the first model of Lewin (1946) that was adopted later by researchers like Taba-Noel (1957) in which the model was regarded as scientific action research within the positivist paradigm. A key idea of these models was that social processes could be studied by introducing changes and observing scientifically the effects of these changes [(McKernan 1991) p. 17].

A practical-deliberative action research model, which places the emphasis on understanding practice and solving immediate problems, was developed by Elliot (1978) and Ebbutt (1983) and was associated with the interpretive paradigm [(McKernan 1991) p. 20-24; (Hopkins 1993) p. 49-50]. Elliot (1978) and Ebbutt (1983) held the vision of action research as a way to improve the quality of life in a social situation [Elliott, 1981 in (McKernan 1991) p. 23]. Later, Carr, Kemmis and McTaggart (1988) developed a critical-emancipatory educational action research approach, which maintains that critical enquiry enables practitioners not only to search out the interpretive meaning that educational actions have for them, but to organise action to overcome constraints [(Hopkins 1993) p. 48-54; (McKernan 1991) p. 15-28].

One of the aims of action research is to solve the immediate and pressing day-to-day problems of practitioners for the purpose of improvement of, and involvement in, practice [Grundy and Kemmis, 1982 in (Potter 1999) p. 220; (McKernan 1991) p. 4]. Another aim of evaluation action research can be simple appraisal carried out by an individual teacher into an aspect of the curriculum [(Hitchcock and Hughes 1995) p. 6]. Yet another form of evaluation action research is the approach of research-based teaching and self-evaluation suggested by Stenhouse (1975,1983), in which an emphasis is placed on developing the practical skills and understandings necessary for those involved in programme assessment as well as to evaluate their own practice [(Potter 1999) p. 220].

Evaluation action research is based on the assumption that the driving force for evaluation, its questions, issues and foci should arise from the understandings of those working within the programme [Simons, 1987, in (Potter 1999) p. 220]. Therefore, a key premise of action research is that behaviour or actions must be studied in the field or *in situ* by the practitioners [(McKernan 1991) p. 5-7]. In evaluation programmes the evaluator studies an educational activity *in situ*, or as it occurs naturally without constraining, manipulating or controlling it [Worthen and Sanders, 1987, in (Hitchcock and Hughes 1995) p. 35].

Although many writers suggest that action research is more efficient as collaborative research, it is possible to carry out action research by oneself [(Kochendorfer 1994) p.135, Kemmis (1983) in (Hopkins 1993) p. 44], when the researcher is a participant observer who introduces materials and procedures for teachers and learners. Participatory action research (PAR) is about change and transformation, and explores new approaches to empower the oppressed and has a strong emphasis on participation and collaboration [(Babbie and Mouton 2001) p. 64].

Participatory action research is also associated with critical theory, which attempts to reveal those factors that prevent groups and individuals taking control of, or influencing, those decisions which crucially affect their own lives [Gibson 1986, in (Hopkins 1993) p. 46]. In other words, the critical evaluation researcher is action oriented, working to change the world and transform the social order [Fay, 1987, in (Potter 1999) p. 219; (Babbie and Mouton 2001) p. 63], in which critique is an important step in understanding, interpretation and emancipation [(McKernan 1991) p. 33]. In this context emancipation refers to the process involved in liberating teachers by giving them greater autonomy and empowering them to take decisions regarding curriculum implementation, classroom situations and their own practice [(McKernan 1991) p. 33; (Hopkins 1993) p. 35]. It can also emancipate learners by encouragement of independent thought and argument [Stenhouse 1975, in (Hopkins 1993) p. 35], and it can liberate those who suffer repressive and unjust practices by developing an awareness of them and empowering individuals or groups to change such practices [(Potter 1999) p. 221; (McKernan 1991) p.

33; (Babbie and Mouton 2001) p. 59]. In this approach conclusions from formative evaluation can be applied during the continuation of the intervention programme, contributing to the empowerment of learners and to help them to fulfil their potential. Participatory action research is therefore a basis for personal and professional growth and development, and empowers individuals to become independent reasoners.

3.3.5 Action Research in My Project

In view of the aims of this research, which were to design an intervention programme to teach thinking skills to learners with special needs, implementing it by myself, collaboratively reflecting on it, and evaluating it using qualitative and quantitative data producing techniques, it fitted best within a participatory action research approach (or paradigm) [(Babbie and Mouton 2001) p. 58]. The research took place *in situ*, collaboratively with the classroom teacher, who mainly observed and reflected on the lessons as well as the learners' achievements and change, with the purpose of promoting improvements and change in practice. It also fits into the general aim of action research, namely empowering learners by developing cognitive functions and enabling them to take decisions on their own. Conducting the research also triggered my professional development and growth as a teacher, researcher, curriculum developer, evaluator and as a person. Both of these aspects – the teacher's and the learners' empowerment – can be loosely framed as forms of emancipation by developing an ability to decide for oneself as well as being liberated from the system constraints. This in turn involves developing a critical point of view to evaluate the intervention by my learning to appreciate criticism from the classroom teacher for the purpose of my own improvement and professional growth, as well as developing a self-critical point of view about what is considered as good as a teacher, researcher, etc.

Therefore, my study is loosely framed within a critical-emancipatory paradigm using an evaluation action research (EAR) approach. Action research was used in the study for the purpose of improving the teaching of science to learners with special needs and to involve them actively in the teaching/learning process.

I designed an intervention programme to teach thinking skills to learners with special needs. The project started from a programme design that included the planning of the intervention programme by integrating thinking skills into the science curriculum. Planning was followed by implementation of the intervention programme to grade 6 learners, and evaluation of the first cycle of inquiry. Analysis of the first cycle findings regarding the learners' progress, change in practice and the intervention programme effectiveness, led to re-planning, so that changes were introduced into the intervention programme. Implementation of the revised intervention to grade 5 learners served as the second cycle of inquiry, which was followed by another process of evaluation.

Although I dealt with two separate cycles of inquiry with two different sample groups, the teaching style, the content area and the principles, which guided the design of the intervention programme, were similar, hence, providing a partial sequence between the two cycles of inquiry. Though the second cycle was not meant to improve the extent of the intervention applied during the first cycle of inquiry, the findings of the first cycle of inquiry were used to introduce changes before the second cycle of inquiry started, and enabled me to provide evidence for dependability, which I discuss later in the chapter. Therefore, conclusions will be drawn from both cycles.

3.3.6 The Context of the Research

The research took place in the Pro-Ed private school that was founded in 1998 in Rondebosch, Cape Town, by Dr Anita Worral for learners with special needs. The mission statement of the school is to help learners with special needs to progress in a safe, encouraging and structured environment by recognising the unique learning style of the child and providing him/her with alternative and focused learning methods [Pro-Ed Brochure]. The school ethos, shared by learners, their parents and staff members, is to set boundaries, reward positive behaviour and encourage respect and consideration for all [Pro-Ed Brochure].

The school has small classes, with a maximum of 12 learners in every classroom, and has about 80 learners in total, with ages ranging between 6 and 15. The school caters for learners with learning disabilities such as Attention Deficit Hyperactive Disorder

(ADHD), mood disorder, dyslexia, among others, who mostly come from high socio-economic backgrounds (learners pay about R2500 a month to be educated in this school). The school employs experienced teachers, remedial teachers and psychologists, speech and occupational therapists, and physiotherapists carry out multidisciplinary interventions. The school prepares an individual education plan (IEP) for each learner with long-term and short-term goals in literacy and mathematics as well as in life and social skills. Computers are used to enhance learning and homework classes are provided as well as thinking skills interventions. The mainstream South African curriculum is followed, but presented in ways best suited to individual learning patterns [Pro-Ed Brochure].

When the IEP is complete and the learners achieve the required level for the mainstream curriculum, mainly in literacy and numercy, or when the parents and teachers agree that it would be beneficial for the learners, the learners are placed back in mainstream schools.

3.3.7 Target Groups of the Research

Two classes of 12 Grade 6 learners and 12 Grade 5 learners from the Pro-Ed school will serve as the purposive sample.

Purposive sampling or judgement sampling uses the judgment of an expert in selecting cases or when cases are being selected with a specific purpose in mind, [(Bernard 2000) p. 176, (Newman 2003) p. 213 (Terre-Blanche *et al.* 1999) p. 281]. This is used often when the research is intensive, or when researchers look for a community, a hospital or a school system that reflect the things they are interested in [(Bernard 2000) p. 176]. Also, 'there are a myriad of contextual variables operating on schools and classrooms (e.g. community culture, teacher personality, school ethos, socio-economic background, etc.) that would affect the results of the research' (and, which are difficult to overcome in terms of random sampling) [(Hopkins 1993) p. 39]. Since I as a science teacher-researcher am concerned with the individual progress of learners with special needs, rather than the sum score from the class or the school, this type of sampling suited my needs.

The sample is convenient for the following reasons:

1. The class sizes are small, which will enable me to work with each learner according to his/her level of development and rate of progress;
2. Grades 5 and 6 learners should be able to develop these thinking skills and processes [(Hester 1994), (Department of Education 2002)];
3. IE is a programme suitable for learners with special needs [(Arbitman-Smith and Haywood 1980; Feuerstein *et al*. 1981)];
4. Using two different grades will allow me to embed the intervention programme into two different curricula in science and by that increase the validity of the programme;
5. The permanent classroom teacher has a wealth of experience. He is a science teacher who was trained in IE and had practised mediated learning for three years. The permanent teacher knows the class learners and, because he was present in all lessons, provided a natural environment and security for the learners, as well as the ability to collaborate in evaluation of the programme.

3.4.8 Negotiation of Access

In the instrumental enrichment training course given at the Pro-Ed school in April 2002 I met the classroom teacher of the Grade 6 learners for the first time, the principal of Pro-Ed school and the deputy principal of the school, who also participated in the training course.

When I decided to conduct my research, I met the classroom teacher and described the programme to him. Having his consent to become part of the research, we agreed that both of us would teach the programme which I had designed for teaching thinking skills in science using IE principles in his classroom. He also agreed to reflect on the process with me after each lesson, and we discussed the use of video as a way to document the intervention programme.

I wrote a letter to the director of the school, Dr Anita Worrall, in September 2002 asking for permission to conduct my research in the school, explaining the rationale behind the programme, the topics to be covered and the skills to be taught (see Appendix A for copy of letter). The methods I would use were also mentioned in the letter as well as my commitment to make all information produced in the study available to the school. My supervisor, Prof. Lesley le Grange, sent her a letter to confirm that I was an MEd student at Stellenbosch University. Although I did not receive a written letter from the school, the classroom teacher and the school principal gave me permission to conduct the research in the school.

Eventually I taught the whole course, while the classroom teacher observed the lessons and took notes about what transpired in the classroom. There were two main reasons why I taught the whole programme. First, since I designed the whole programme it was important to me that the implementation of the intervention programme would be in line with what I had in mind. That implied that I must be the one to teach it, even though I was a bit concerned about my ability to teach in English. After trying it out, I realised that I am able to teach in English in a satisfactory manner, and so language was not a major barrier to teaching. However, there were times when I struggled to find specific vocabulary, especially when incorporating different ideas from other situations to demonstrate a specific idea in science. Nevertheless, the lessons were fluent and the learners as well as the classroom teacher did not consider language as a major problem. Secondly, I realised the enormous benefits I would gain in terms of practising the mediational style, and it was worthwhile and important to practice this in both cycles of inquiry.

At the end of the first cycle I sent a letter summarising the mini-programme lessons and activities held in the classroom and thanked the school director for giving me permission to conduct the research.

Before the second phase, in March 2003 I wrote another letter to Dr Worrall to get her permission for a second cycle of inquiry and my supervisor, Prof. Lesley le Grange, confirmed that I was a PhD student at Stellenbosch University. I received a letter from Dr Worrall to confirm that I could proceed with my research in her school. At the end of the second cycle I thanked the director of the school, and gave the school a copy of all the worksheets and tests used in the lessons and a description of what was learnt. (Most of the correspondence has been included in Appendix A.)

3.4.9 The Intervention Programmes

I designed and implemented two intervention programmes, one for the Grade 6 learners and the other for Grade 5 learners. Eighteen lessons were designed in both intervention programmes around science content knowledge from the science textbook, as recommended by the classroom teacher [(Cadle *et al.* 1995b) for the Grade 6 learners and (Cadle *et al.* 1995a) for the Grade 5 learners]. Though it was the book for the 1995 syllabus, the classroom teacher and other staff members still used it and I followed the programme as recommended by the school. Nevertheless, I used various sources of material from other books and encyclopaedias to supplement the material available [for example, (Clacherty *et al.* 1998), which was written according to Curriculum 2005; other material was adapted and appears in Appendix B].

The thinking skills I chose were recognised by the Commission of Science Education of the American Association for Advancement of Science (AAAS). These skills are known to be representative of problem-solving activities and can also be used in everyday life [Gange, 1970 in (Shaw 1983)]. These skills are in line with the list of thinking skills and processes for Grades 5 and 6 as recommended for Natural Sciences Learning Area of the Revised National Curriculum Statement [(Department of Education 2002)]. Some of the lessons included exercises from IE instruments in order to practise and emphasise a specific skill (see Appendix C). Science content knowledge and related experiments were conducted in the classroom, followed by discussions and bridging to everyday life.

For the Grade 6 learners I chose to teach the following skills and approaches: six-steps approach to planning, following instructions, measuring, inferring, comparing, classifying and experimenting, as selected thinking skills for the period of one term. *'Solutions'* and *'Food and Feeding'* were the science content knowledge I used as a vehicle to practise the thinking skills. I organised two educational outings to Rondebosch Common to collect insects, so that learners could characterise their feeding habits and habitats, as well as one educational outing to the Two Oceans Aquarium to learn more about the feeding habits of sea organisms.

For the Grade 5 learners I chose the following skills and approaches: six-steps approach to planning, measuring, comparing, classifying and experimenting, as selected thinking skills for the period of one term. *'Phases of Matter'* and *'Water'* served as the science content knowledge. I organised an educational outing to the MTN Science World, where learners were exposed to science phenomena and practised some of the skills we learned in the classroom using a worksheet I prepared for them (see Appendix B).

3.4 The Methods of the Research

Hughes (1971) claims that the subject matter of sociology is interaction and that conversation of verbal and other gestures, is almost a constant activity of human beings [cited in (Heath and Hindmarsh 2002) p. 99].

One way to characterise the interactions in the learning-teaching situation is by carrying out small-scale research in the form of a case study, which will be discussed in the next section. A variety of techniques and methods were used in this study. Some of the methods were used to capture the behaviour of participants in the study, namely the teacher-researcher and the learners, while other techniques were used to obtain a better understanding of cognitive abilities and mediation. I tried to produce data *in situ*, which will reflect reality as close as possible. The use of a multi-method approach for the study serves as a way to validate the data through triangulation, which will be discussed later in this chapter.

3.4.1 Case Study

Case studies are widely used across a number of disciplines and can be described as a providing the 'story' of a certain aspect of social behaviour in a particular setting over a defined period of time [(Hitchcock and Hughes 1995) p. 317]. Case studies are usually rich in details, presented in a chronological narrative of events, with a focus on individuals or groups in particular situations, and researchers are usually involved in the case [(Hitchcock and Hughes 1995) p. 317]. Hitchcock and Hughes further explain that 'in educational evaluation or research, a case study may study and portray the impact in a school of a particular curriculum, innovation, explore the experience of staff development, trace the development of an idea through a number of social organisations, investigate the influence of a social and professional network, or portray a day in the life of a teacher, administrator or a pupil' [(Hitchcock and Hughes 1995) p. 321].

Yin (1984) defined three types of case studies:

- Exploratory case study, which is basically a pilot to large-scale research and used to generate research questions or to try out data collection methods;
- Descriptive case study, which is highly detailed and low in theory, and gives a narrative description of life;
- Explanatory case studies, which generate a new theory or test an existing one [Yin (1984) in (Hitchcock and Hughes 1995) p. 321].

Merriam (1988) classified case studies into descriptive, interpretive and evaluative case studies. She distinguishes between the descriptive case study, which is a narrative of a sequence of events, atheoretical in the sense that basic description of the subset comes before hypothesising or theory testing, and an interpretive case study, which is used to develop conceptual categories or to challenge existing assumptions. Both are rich in details, but the interpretive study is theoretically oriented. The evaluative case study, according to Merriam (1988), is a combined description and explanation with judgement, which is the essence of sound evaluation [Merriam (1988) in (Hitchcock and Hughes 1995) p. 321].

It was argued that 'case studies have a particular value where the research aims are to provide practitioners with better or alternative ways of doing things' [(Hitchcock and Hughes 1995) p. 322], which is at least part of what action research is all about. Another advantage is that the information yielded by case studies tends to give an accurate and representative picture, since it was produced by many methods [(Hopkins 1993) p.143], and the generalisability of case studies is demonstrated through showing the linkage between findings and previous knowledge [(Babbie and Mouton 2001) p. 283].

According to these classifications, this project is an *explanatory case study* or *evaluative case study,* which describes, explains and evaluates the intervention programme I wrote, as well as ties it to previous theories concerned with teaching thinking skills and generates new ideas about this, especially with regard to science and special education.

Case studies depend strongly on triangulation to validate findings and usually a range of techniques will be used to obtain data and different points of view will be presented. Triangulation will be described in more detail in the next section.

3.4.2 Triangulation

Triangulation may be defined as the use of more than one method of data collection, from as many sources as possible, in the study of some aspect of human behaviour [(Cohen and Manion 1994) p. 233; (Terre-Blanche and Kelly, 1999) p. 128]. It is generally considered to be one of the best ways to enhance validity and reliability when the type of data produced is qualitative [(Babbie and Mouton 2001) p. 275]. Triangulation provides a way to approach a situation from as many angles as possible, and to get a fuller and more realistic view and a better understanding of the phenomenon studied [(Terre-Blanche and Kelly, 1999) p. 128]. Since social sciences often study complex and rich situations having more than just one viewpoint, like interactions between people and learning-teaching processes, an exclusive reliance on one method can lead to biased or misleading results. By using various methods the researcher can be more confident about his/her generated results, and the more the methods contrast with each other, the greater the confidence in his/her findings [(Cohen and Manion 1994) p. 233-4]. One can use a variety of qualitative and quantitative methods to obtain different kinds of information, which potentially increase the validity of data and consequently add depth to the analysis [(Cohen & Manion, 1994) p. 233; (Hitchcock and Hughes 1995) p. 180].

In addition, triangulation is a way to overcome problems in social sciences like method-bound problems, culture-bound problems, time-bound problems, as well as other problems [(Cohen and Manion 1994) p. 234]. Denzin (1970) developed six different forms of triangulation [in (Cohen and Manion 1994) p. 236, or (Kelly 1999a) p. 430], which I will list below:

- Methodological triangulation is the use of more than one method in one study, and is often referred to as multi-method research;
- Time triangulation takes into consideration the factors of change by utilising cross-sectional and longitudinal designs;

- Space triangulation tries to overcome problems of studies conducted within one culture or subculture by incorporating cross-cultural techniques;
- Theoretical triangulation that tries to make use of competing or alternative theories;
- Investigator triangulation that engages more than one observer;
- Combined levels of triangulation, which make use of the individual level, the group level and the society level.

Out of these, methodological triangulation is the one used most frequently in education and the one that has the most to offer [(Cohen and Manion 1994) p. 239].

Triangulation can also be done by cross-referencing, for example, different perspectives obtained from different sources [(Hitchcock and Hughes 1995) p. 180]. Elliott and Adelman (1976) write: 'Triangulation involves gathering accounts of a teaching situation from three quite different points of view; namely those of the teacher, his [*sic*] pupils, and the participant observer… The teacher is in the best position to gain access via introspection to his [*sic*] own intentions and aims in the situation. The students are in the best position to explain how the teacher's actions influence the way they respond in the situation. The participant observer is in the best position to collect data about the observable features of the interaction between teachers and pupils' [in (Hopkins 1993) p. 152-153].

Methodological triangulation enables me as a teacher-researcher to describe the learning-teaching experience from the teacher's, the learners' and the observers' points of view. In order to get the teacher's point of view, I recorded all lessons using a video camera and I reflected on my feelings, thoughts and plans in teaching in a personal journal. This was triangulated by the classroom teacher, who served mainly as an observer and evaluated my teaching abilities, strategies, material, creativity, mediation and bridging.

The learners' scholastic achievements were evaluated formatively and summatively, using quizzes and class work sheets as well as vocabulary use, ability to explain and metacognitive awareness as it came through the video material. This was also triangulated by the classroom general evaluation as this transpired from our informal conversations, reflections and the interview conducted with the classroom teacher after each inquiry cycle. The learners' feelings and thoughts were captured in questionnaires they had to complete every second week.

The learning-teaching situation was evaluated by both the classroom teacher and myself through the video material, since in this respect both of us acted as observers.

Trustworthiness is another way to enhance validity. I will briefly discuss this in the next section.

3.4.3 Trustworthiness

The principle of trustworthiness depends on ways to persuade the audience, including the researcher him/herself, that the findings of his/her inquiry are worth paying attention to or worth taking account of [(Babbie and Mouton 2001) p. 276]. According to Babbie and Mouton (2001), a qualitative study cannot be called transferable unless it is credible, and it cannot be deemed credible unless it is dependable. These three elements, namely credibility, transferability and dependability, constitute trustworthiness.

Credibility can be achieved through a few procedures:

- Prolonged engagement of the researcher in the field until saturation occurs;
- Persistent observation;
- Triangulation (as explained above);
- Referential adequacy, which refers to what materials are available to document the findings. Audio and videotaping provide a good record;
- Peer debriefing, which is done with a similar status colleague that is outside the context of the study;
- Member checks which check the data and its interpretation [(Babbie and Mouton 2001) p. 276-277].

Transferability refers to the extent to which the findings can be applied in other contexts or with other respondents. In critical-emancipatory and interpretative research approaches, the researcher does not maintain or claim that knowledge gained from one context will necessarily have relevance for other contexts or for the same context in another time frame [(Babbie and Mouton 2001) p. 277]. Rather the obligation to demonstrate transferability rest on whoever wishes to apply the same study by following the thick description the researcher provides to create similarities between the studies [(Babbie and Mouton 2001) p. 277].

Dependability can be achieved when the researcher provides evidence that the study is repeated with the same or similar subjects in the same or similar contexts - the respective findings would be similar [(Babbie and Mouton 2001) p. 278].

To increase the trustworthiness of this project, I tried to increase credibility by using triangulation, videotaping the intervention programme and partial member checking (only with the classroom teacher). I applied my programme twice to two independent groups of learners to provide evidence for dependability.

I will now turn to a discussion on the processes of data production.

3.4.4 Data Production

I produced data over two cycles of inquiry: the first cycle took place in 2002 and the second in early 2003. As a teacher-researcher I designed 18 lessons around science thinking skills and processes that are in line with requirements set out in the revised National Curriculum Statements for the Natural Sciences Learning Area. I proposed to teach these lessons over a period of one school term, and evaluated my teaching and learners' progress formatively throughout this period. During the term I taught twice a week for a period of one hour. Learners answered 7 questionnaires (see Appendix D) regarding their feelings and understanding of science skills and content every alternate lesson in the first cycle, and 5 questionnaires (see Appendix E) in the second cycle. The teacher-researcher's and permanent teacher's direct observations were augmented with a short collaborative reflection on the lesson, highlighting its main advantages and disadvantages. All the lessons were videotaped, viewed, transcribed by myself and analysed after every lesson. Learners completed four quizzes (every two weeks, see Appendix D for Grade 6 quizzes, Appendix E for Grade 5 quizzes) and all classroom tasks-sheets were handed in to me for purposes of evaluating learner's achievements formatively and summatively (see Appendix B for all worksheets of adjusted material). Each reflection on a lesson was intended to bring new insights and lead to the improvement of the next lesson. Two semi-constructed interviews with the permanent teacher were conducted at the end of each major cycle of inquiry and were concerned with the effectiveness of the programme, the learners' progress, and his critique on the programme and lessons as such. (See Appendix F for both questions and full interview scripts with the classroom teacher).

Lastly, I kept a personal journal that I used to reflect on my feelings and thoughts during and after the lesson, and as a basis for introducing changes throughout the teaching period.

3.4.5 Observation using Video

It is difficult for a teacher-researcher to observe interactions between him/herself and the learners, learners' response and the lessons' events since he/she is busy teaching. I decided that this problem could be overcome by videotaping the lessons, which enabled me to view the interactions between the learners and myself, view learners' reactions to material presented to them and their actions during different activities, and view to my own teaching [(Heath and Hindmarsh 2002) p. 103].

Videotaping is useful, because it provides a permanent record of what was actually said and how it happened as opposed to the researcher-observer's thoughts and interpretations of the situation. I adapted a routine recommended by Plowman (1999, p. 6) of viewing videotapes immediately after each lesson and took notes of my feelings/thoughts/ideas of what had transpired in the classroom. I also viewed the videotapes a second time at the end of each cycle as many times as needed. In this way I could reflect immediately on each lesson and introduce some of my insights into the programme, in addition to gaining a detached point of view of the programme as a whole.

The camera was placed before the learners entered the classroom and was in a stationary position during the lessons so as to make sure that the learners are distracted as little as possible [as recommended by (Heath and Hindmarsh 2002) p. 108]. Although the camera provoked comments at the beginning, learners forgot about it a few minutes after the beginning of the lesson and most of them disregarded it entirely, which happens often when video cameras are present in classrooms [(Plowman 1999) p. 3]. Nevertheless, in both cycles there were one or two learners who were self-consciousness and were aware of the camera, commenting about it or looking straight into the lens, and therefore probably influenced by its presence. This is one of the major drawbacks of using video as a research technique.

Following preliminary analysis I chose better angles of setting the camera to make sure most of the activities were recorded and so that I could get a better view of the learners. Since the camera was placed facing the learners and due to the setting of the classroom and the way learners sat I was not always in the frame. In spite of this, my voice was captured thoroughly while I was teaching.

I had an access to a video camera via the University of Stellenbosch media centre, which allowed me to use it for the whole term. This in turn provided the opportunity to videotape our outings to Rondebosch Common, as well as both interviews I had with the classroom teacher.

I watched the videos in the media centre and spent about 50 percent more time to view them than the actual time of the lesson. This is a time-consuming exercise and transcribing the lesson took double the time of the actual lesson. Nevertheless, once it was transcribed, it served as the most complete detailed record of each lesson.

Since thoughts, feelings, attitudes and perceptions are potentially important data which cannot be observed through video recordings, they were supplemented by other methods including questionnaires, tests and formative evaluation of the learners, formal and informal conversations with the classroom teacher as well as interviews with him.

3.4.6 Questionnaires

Questionnaires are a quick and simple way to get information from learners regarding different aspects of the learning-teaching situation, about the curriculum, teaching methods and about issues regarding the subject matter. Questionnaires are easy to administer and easy to follow up, although they are not flexible and their effectiveness relies on comprehension and ability to read as well as on the motivation and commitment of the learners [(Hopkins 1993) p. 136].

The way in which a questionnaire is constructed is very important and I followed guidelines recommended in the literature [(Wellington 2000); (Best 1977); (Kanjee 1999)]. These include usage of familiar words and simple questions, relevant and short questions/statements, and avoiding leading or vague questions. I adapted ideas to my needs from the Likert Scale Method of Summated Rating [(Best 1977) p. 170], which usually includes statements regarding a subject and the respondents had to indicate to what extent they agree or disagree with the statement using a given scale.

The aim of the questionnaires was to obtain information about the programme, the learners' understanding of the skill and subject matter, and their feelings regarding the methods I used. The analysis of these questionnaires was partly done in order to improve the programme to suit the learner's needs as the programme proceeded. For this reason I administered a questionnaire every week, which took about 10 minutes to complete. All of questionnaires included 10-12 short and straightforward statements regarding the relevant skill or process we used that week and the subject matter related to it. Three open-ended questions were also included and learners had space to write down their opinions or feelings in their own words.

In the first cycle I used a five-point scale and the learners had to tick their answers according to a specific code found in a table (see Appendix D for examples). In the second cycle I changed the table into a scale of faces (happy to sad, see Appendix E for examples) and they had to circle or colour it. The purpose was to increase motivation and commitment of the younger learners by presenting the questionnaire in a more appealing way.

3.4.7 Interviewing

A successful interview is a dynamic interpersonal experience that is carefully planned to accomplish a particular purpose [(Scott and Usher 1996) p. 309]. Interviews can be used in curriculum evaluation and they can help throw light on a number of aspects of both the learners' and teachers' experience and about their interactions [(Hitchcock and Hughes 1995) p. 163]. This could be done, for instance, as a structured, semi-structured or open-ended interview. A semi-structured interview is a more flexible version of the structured interview, since it allows the interviewer to probe the interviewee's response; however, it is based on prepared questions [(Hitchcock and Hughes 1995) p. 157]. In other words, it allows the interviewer a greater scope in asking questions out of sequence and provides a better flow of information between the researcher and the subject [(Hitchcock and Hughes 1995) p. 162].

I conducted two interviews with the classroom teacher, one just after the first cycle, and another one at the end of the second cycle, which included questions regarding both cycles (see Appendix F for interviews scripts). Although we had many informal conversations during the programme and reflected on the teaching immediately after each lesson, an interview was appropriate since it was more focused and more complete than the previous methods mentioned. It helped me to obtain a richer and broader picture of the programme from the perspective of the classroom teacher. Both of the interviews were semi-structured interviews, which included prepared questions regarding the purposes of the study, learners' progress and their reaction to the programme, and he also evaluated my personal growth as a teacher and as a mediator.

After conducting each interview I reflected on the teaching experience and wrote down my feelings and thoughts about the interview. Both interviews were videotaped and transcribed.

3.4.8 Personal Journal

In order to keep a record of my thoughts and feelings regarding each of the lessons, and as a way to keep track on some informal conversations with staff members and especially with the classroom teacher, I kept a personal journal. According to Hitchcock, 'the value of the keeping a journal or a diary is as much emotional as it is technical or analytical', and it is a way to 'reflect on the research, to step back and look again at the scenes in order to generate new ideas and theoretical directions' [(Hitchcock and Hughes 1995) p. 134]. Keeping a diary is a simple way in which one can record events, which might help to relate incidents and explore emerging trends, and it is very useful if the teacher-researcher intends to write a case study [(Hopkins 1993) p. 117].

Since one of my research aims was to improve the teaching as the programme proceeded, and since action research is based on reflection during the study, keeping a personal journal was very appropriate and suited my needs. This was further supplemented by self- and collaborative reflection, which I shall discuss below.

3.4.9 Reflection and Praxis

The rationale for reflection is the idea that one can move beyond the immediate situation to a reflective state, which means looking critically at the situation from a distance and from a researcher's point of view [(Hitchcock and Hughes 1995) p. 10-11]. It has been argued that both subjectivity and reflexivity are necessary for valid interpretation, since in order to develop an understanding of social life, one must get involved in it, and without this understanding it is impossible to evaluate a programme [(Potter 1999) p. 215]. The development of critical awareness is through an ongoing reflective process termed 'praxis' which could occur both individually and collectively [(Potter 1999) p. 220].

Following Hitchcock and Hughes (p. 103) I included a reflexive account at the end of each lesson, where I tried to be open and critical, and as honest as possible about the strengths and the weaknesses of the lessons or activities, as well as problems encountered and solutions found. To ensure that effective and improved mediation took place, the permanent teacher and I collaboratively reflected on my teaching skills and abilities, as well as on changes in learner's progress.

For the purposes of data analysis and in order to evaluate the programme as a whole, I focused on two aspects: the teaching process concerned with the teacher-researcher's teaching abilities and the learning process focusing on the learners' abilities and achievements. A detailed explanation is given in the next section.

3.5 Data Analysis

Data analysis consisted of a few steps followed as a sequence for each lesson. At the end of each sequence the lesson as a whole was evaluated focusing on individual learners and the teacher-researcher. I was focusing on learners' progress in terms of use of thinking skills and processes, use of vocabulary and understanding of science concepts and content knowledge. I was also focusing on my abilities to mediate, use of bridging and mediation of principles and rules, teaching style and questioning, which will reflect on my ability to teach in a mediation teaching style. This is a more detailed description of each step taken:

1. I watched every videotaped lesson and transcribed it, indicating who the speakers are and what the different activities were. This idea was adapted from Heath and Hindmarsh (2002), who further explained that the transcription does not replace the video recording as data, but rather provides a resource through which the researcher can begin to become more familiar with details of the participants' conduct [(Heath and Hindmarsh 2002) p. 109]. The transcriptions were recorded in detail, quoting as accurately as possible learners' responses and that of the teacher-researcher. The information was written on record cards that served as devices to enable the teacher-researcher to identify particular actions and to preserve a rough record of what had transpired.

2. The second stage was to combine new themes that emerged in the first step with previous ideas and feelings that I produced from the reflection notes of both the permanent teacher and my own. This information was used mainly to develop a wider evaluation of the lesson.

3. The third step was to construct a personal evaluation of each learner, analysing his/her performance in the classroom tasks and quizzes, combining information from questionnaires, and picking up indications of progress as reflected on the record cards of the transcribed videos. Units of meaning were produced such as a quote, a micro-change in behaviour or an achievement that might have some meaning. This idea was adapted from Maykut and Morehouse's [(1994), p. 134] description of the comparative method of data analysis. They used the units to compare different responses from a large-scale study, whereas in this instance I worked with only 12 learners. Therefore instead of connecting relevant units from different participants to create a category, I used the units of meaning to build a record of changes in progress, attitudes and characteristics of every individual learner. The accumulative data reflected learners' experiences. These were also recorded on cards. The results of all

data produced from different sources for each learner were available on one record card (some examples (in Hebrew) in Appendix G).

4. The fourth step was to evaluate the teacher-researcher's own progress as a teacher, as perceived from watching the video, my own reflections at the end of each lesson, and the reflections I undertook collaboratively with the classroom teacher. A summary of the evaluation of the teacher-researcher was recorded on a record card.

5. The last step was to evaluate the learning programme outcomes that the teacher-researcher determined prior to the commencement of the programme in the light of the data produced in steps 1 to 4.

3.6 Ethics in Research

Ethics refers to issues of research responsibilities towards the subjects in the study. In action research the ethical principles go beyond the usual concern for confidentiality, anonymity and respect for the persons who are the subjects of enquiry, and define in addition appropriate ways of working with other participants in the social organisation [(Hopkins 1993) p. 221]. I followed several guidelines by Kemmis and McTaggart (1981; p. 34-44) as they appear in Hopkins (1993; p. 221-223):

I consulted and informed the relevant persons and authorities and got the necessary permission to conduct my research in the school, to observe and record the activities with my learners, and to collect the worksheets and tests they completed in my lessons. I encouraged members of the school to help me shape and improve the work. I kept the work visible and remained open to suggestions so that authorities and colleagues could disagree; the videos were made available for viewing by any staff member who had any concerns about the programme. I kept the school informed about the programme, providing them with lessons' descriptions, worksheets, tests and questionnaires. I obtained permission from the classroom teacher to cite sections of the interviews we had, and I gave him copies of the interviews for his consent and approval. With respect to the learners, confidentiality was maintained throughout the work, and learners' names were coded. At the start of the programme I described to the learners what it entailed, informing them about the usage of the video camera, and also asked for their co-operation with answering questionnaires and tests.

3.7 Summary

This chapter outlined the framework of this study in terms of the methodology chosen as well as the methods used to produce data.

This study is loosely framed within a critical-emancipatory paradigm, in which action research served as a way to evaluate the intervention programme's effectiveness and as a way to introduce changes to improve teaching practice. This study was triangulated to increase validity by the use of various methods to provide the teacher's, the learner's and the observer's points of view on the learning-teaching situation. In this regard questionnaires, interviews, videotaping and formative evaluation over time were combined to create a whole picture of the learning-teaching situation.

In the next chapter I am going to present in detail the findings of two cycles of inquiry; they will be referred to as two separate case studies. The findings will be presented around specific themes, which reflect on each of the study purposes, and a few new themes, which were not predicted and emerged as the study proceeded.

Chapter Four

The Findings of Two Cycles of Inquiry

4.1 Introduction

In this chapter I am going to present the findings of the two action research case studies; each represents one cycle of inquiry and is concerned with evaluating the intervention programme I had designed and implemented.

The research findings will be presented so as to follow each of the intervention programmes' aims, which are specified under the research design in the methodology chapter (Chapter 3). Additionally, I discuss a few issues at the end of my description of each cycle. These issues emerged during the research, but were not addressed intentionally.

The findings will be organised in relation to the following themes: the development of science thinking skills and their transfer, acquisition of content-knowledge, the suitability of the intervention programme to the learner's needs, the learners' engagement in the science classroom, and the intervention programmes' influence on the learning environment. In addition, the mediational teaching style and problems in communication will also be discussed. Each theme was constructed from data produced from different sources using various techniques, which were merged together to throw light on the intervention programme's effectiveness. Quizzes and worksheets were used to reflect on learners' scholastic achievement and questionnaires were administered for reflection on learners' opinions and feelings. These were supplemented by the classroom teachers' reflection on different issues, as they transpired from formal and informal conversations between the teacher and myself as well as from the interviews I conducted with him.

I introduced some changes into the intervention programme before the second cycle of inquiry in order to meet the Grade 5 learners' needs, and I will discuss the reasons for these changes. The second cycle's findings will follow the same structure as those of the first cycle, by addressing each of the intervention aims using all sources of data combined.

I will now turn to a description of the first cycle's findings.

4.2 First Cycle of Inquiry - Case Study I

As mentioned the first cycle of inquiry took place in Pro-Ed School, which was founded in 1998 for learners with special needs and is situated in Rondebosch, Cape Town. The premise is a complex of old houses that was renovated to cater for the school. The main building houses the school's management team and secretary, multidisciplinary assessment and intervention offices, including those of psychologists, speech therapists and physiotherapists, and the teachers' staff room. The adjacent houses serve as classrooms in which the learners sit in groups of 3-4 learners facing different directions. In each classroom green and white boards are provided on two of the classrooms' walls, and usually one or two computers are available for the classroom teachers' and learners' use. Many of the classroom teachers use the walls to hang posters with relevant subject matter content and some of the learners' works. Each classroom also serves as the classroom teacher's office.

Twelve learners participated in the first cycle of inquiry. The learners were from mixed racial backgrounds: four black learners, one coloured and seven white learners. All the learners came from middle- to higher-class backgrounds (learners had to pay R2500 a month to study in the school). School psychologists evaluate all the learners in order to determine the type of special intervention needed and for how long intervention is required. If the learners are found suitable, the school accepts them.

Before I started teaching, I was informed that all the learners displayed some symptoms of either Attention Deficit Hyperactive Disorder (ADHD) or Attention Deficit Disorder (ADD). Learners differed in their ability to study and displayed very different problems, some of which I was able to identify personally, whilst others I was told about during or after the school term. I learnt more about the learners through informal conversations that I had with the classroom teacher, mainly after I initiated a conversation with him after observing specific behaviours.

In general I gained the impression that above and beyond the objective problems some of the learners manifested in terms of scholastic performance, many of the learners were confronted with problems related to their family situation or background. For example, 5 out of the 12 learners came from a family situation where the parents were either divorced or separated - raising one or more children on their own or with new partners. One of the learners had diabetes; one learner underwent a double organ transplant operation, and one suffered from involuntary movements. One of the learners was adopted after his brother and father were killed in one of the townships, and another learner's father was a convicted drug dealer who had 15 children, 14 of them having the same name as their father. One learner, **Chp,** was diagnosed with the Asperger type of autism. He was impatient, gave up easily when the task was a bit difficult and would respond to certain circumstances with rage. He used to speak out of turn and only the classroom teacher could control him. He was very intelligent but a low achiever and could not participate in most classroom activities without assistance from others; he required a 'one on one' teaching approach.

Most of the learners were present throughout the term and the total sample of questionnaires and quizzes as well as other worksheets for each of the learners was mostly 12. On the odd occasion one or more of the learners were absent due to personal problems or a specific remedial lesson they had to attend. However, when **Chp** was asked to fill in questionnaires and quizzes at the beginning, he simply could not complete the task because he was too anxious and stressed about it. Since I used the questionnaires and quizzes for research purposes, as a way to evaluate the intervention programme and the participation of the learners were supposed to be voluntary, I did not force **Chp** to complete them. I included only those tasks he chose to complete orally or with assistance from the teacher or his peers, as well as his comments from our classroom discussions and activities. For this reason some of the references to samples might mention only 11 participants.

I will now describe the development of learners' thinking skills in science, which were explicitly taught throughout the intervention programme.

4.2.1 Development of Thinking Skills

I designed the lessons in such a way that a specific approach or skill was mediated explicitly and bridged to everyday and scientific tasks so as to meet the first purpose of my research, which was to contribute to the development of science thinking skills in learners with special needs. In the following sections I discuss the main skills addressed in the lessons and present the findings related to these skills, supported by relevant data, as it transpired in the teaching-learning situation.

4.2.1.1 Planning Behaviour

Planning behaviour is an extremely important approach that guides problem solving and can help learners in approaching scholastic tasks. It can also serve as a technique by which one can improve ineffective learning and memory, and help in restraining impulsive behaviour, which learners with special needs may display. I started the intervention programme by mediating a six-step approach to planning, which I adopted from the Instrumental Enrichment (IE) instrument *Organisation of Dots* (*OOD*). There are six steps:

1. Define your goal.
2. Look at what is given - gathering data.
3. Decide on a strategy.
4. Establish the rules or parameters.
5. Decide on the starting point.
6. Check whether the objective has been achieved - check your work [(Hoffman and Feuerstein 1988c) p. 18].

The first unit of the *OOD* instrument (see Appendix C for examples) consists of simple and engaging tasks, through which the above steps can be mediated and they can be applied. The nature of the task is to identify and outline a series of overlapping geometric figures, such as squares and triangles within an amorphous cloud of dots.

Introducing the task to the learners without giving any instructions provoked questions like 'What must we do?' What followed this was a discussion of the need to identify the problem, the importance of data gathering about and from a given task, deciding on a specific strategy to solve it, understanding the rules that are involved, etc. The learners practised the approach using several exercises from the *OOD* instrument.

I chose to bridge the six-step approach to planning to a science context using hypothetical questions, for example, 'How to increase milk production in cows'. We discussed each and every step of the problem, and learners defined the problem they had to solve, came up with ideas on how to access information from books, experts, library facilities and the Internet. The learners then suggested different strategies to increase milk production such as:

Nig: 'the way to get her to produce more milk is by giving her more food…'

Tm: 'you should use better quality of food, not necessarily more…'

Chp: 'spray chemicals to make the grass better…'

K: 'make their system works faster…'

Sa: 'give them more water'

Dm: 'change the type of food…'

Here I mediated the idea that each of those strategies should be considered and can serve as a suggestion to solve the problem, while each of their strategies can be proven wrong after experimenting. I mediated some scientific concepts, which I regarded as rules that guide experimenting, such as control of variables, hypothesis formulation, control vs. experimental groups, etc. Table 1. demonstrates the usage of the six-step approach to plan an experiment.

A general Approach: How to Solve a Problem	**A general approach: How to Plan an Experiment.**	**An Example: How to Increase the Milk Production in Cows**
Define the goal.	The experiment goal.	The goal is to increase the milk production.
Look at what is given.	Gathering data.	Gathering data from books, journals, Internet, and farmers.
Decide on a strategy.	Hypothesis formulation.	Cows that eat more food produce more milk. (**Nig**)
Establish the rules or parameters.	Changing only one variable in each experiment, repetitions and control vs. experimental groups.	Amount of food as a variable, number of cows in each group for repetition and control and experimental groups.
Decide on the starting point.	Details of the specific experiment and methodology.	Experiment duration, food quantity, and measurement techniques as examples for experiment details.
Check whether the objective has been achieved.	Comparing the data to the hypothesis and concluding.	After experimenting, comparing the milk production in the experimental and control groups and concluding.

Table 1: The Six-Step Approach to Design an Experiment

After introducing these steps, learners had to confront similar problems and address them in similar ways.

I will now discuss the learners' competence in using the six-step approach to planning by looking at each step separately.

I found that, from the beginning and throughout the intervention programme, most learners knew how to define goals (8/11) and about half understood what to look for when they checked their work (6/11). 7/11 learners mentioned different sources of information on a specific topic as part of the information gathering after 4 weeks into the programme, and 10/11 mentioned various sources of information by the sixth week; this continued throughout the term. After 4 weeks 8 of the learners could suggest at least one strategy to solve a given problem (similar to what we were doing when designing an experiment), and 10 could do so after 6 weeks. As the intervention progressed learners suggested different ideas, often more creative ones than before, suggesting an increase in creative thinking. For example, in the first quiz, where the learners had to suggest 'how to make less sweet orange fruits', some wrote:

Tm: 'if I give them less sunlight then it creates citrus…'

K: 'if I give it (the tree) more water then it might (she added: 'we think') give you less sweet fruit'

Sa: 'if I spray some toxin then it will improve and if I put the trees in the shade then it won't have so much sun' (no further elaboration).

In the second quiz they had to create red bananas. Some suggested:

Tm: 'if I work with the pigmentation genes of the bananas then I will add red genes to them'

Cht: 'if I put red die in the water then the trees' fruits will go red'

Ty: 'if I put red ink in the banana then maybe it will turn red'

K: 'give them red water then maybe the bananas will come out red'

Gradually an understanding of the act of hypothesising, which involves an assumption or an idea that still needs to be proven, manifested in learners' responses evident in the use of the words *'may'* or *'might be'* when suggesting hypotheses. **K** verbalised this more than once saying, 'we don't know if our suggestion is right and because of that we are going to check' (Lesson 8). In the first quiz only 2/11 expressed an indication of doubt (*might* or *may* be); however, 6/11 of the learners indicated this in the second quiz.

I defined some simple rules to guide experimenting, such as repeating the experiment more than once in order to validate the results, control of variables and changing only one variable in each experiment and comparing control groups with experimental groups before and after a treatment. I mediated the rules and had the impression that learners understood them when we discussed each of them in the classroom. Some of the learners' responses were:

Cht: '…not to use two experiments at the same time because maybe one of them works but you don't know which it is…only one strategy at a time…' (lesson 3)

Nig: 'may be the cow is sick, we have to have more cows, more then one…' (lesson 3)

Da: 'repetition …again and again…' (lesson 3)

K: ' you have to compare before and after so you will know if there is a difference' (lesson 5)

Nig: 'the first time we are not sure that it is really working because something can be wrong so we try again so we're sure that it is right' (lesson 5).

Nevertheless, only half of the learners mentioned these specific rules in the different quizzes (6/11 at the first, 6/11 at the second), while others mentioned other rules, which they thought might be appropriate. Some of the other rules learners mentioned were:

Dm: 'you must not hurt the plant because the tree might die…'

Col: 'don't test with poisonous colours…'

Ter: 'concentrate - because if you are not concentrated you won't be accurate… and looking at what you are doing.'

I think that, although more than half understood some or all the rules I mediated, and could mention them correctly while we were discussing related questions in the classroom, the question regarding the rules in each of the quizzes – it was presented as 'Please indicate two rules and explain their importance' – was formulated in a too general a manner. It might be that this led some of the learners to indicate general rules that guided their work. Another explanation can be that the concepts were too difficult for some learners to grasp and as a result they did not mention them.

Learners started also to use the vocabulary they learned while solving problems in the classroom discussions we had, defining the steps they were using. For example:

Tm: ' By defining my goal and gathering data, I discovered that ...by using what he is wearing and the objects around him, he is a chemist or a scientist' (Lesson 2).

Cht: 'We have to define our goal of what we are supposed to make. We had to make a liquid but we didn't know what was it...we looked at what we had and gathered data: we had water and powder and we had to do something...to put them together...what strategy shall we use: should we measure with the jug or with the measurement cylinder... where shall we start - I followed the instructions... what were the rules: be accurate...' (Lesson 3).

Sa: 'We looked at what we have: we have a measurement cylinder and a beaker, water and spoon. Where shall we start? By adding the water and powder. We mixed it afterwards' (Lesson 4).

K: '... the goal was to write instruction, the strategy was to think when you make tea, what do you do first and all the steps you had to do...' (Lesson 4)

The classroom teacher indicated in the reflection we had after lesson 5 that the learners started using the six-step approach to plan also in Maths when gathering data and looking out for rules, and on one or two occasions they said to him: 'You didn't define the goal...'. In the interview he answered the following question:

> *What changes have occurred/if occurred? On the student's skills level? Did they use it better as far as you can see?*
>
> Let me start off with the very first lesson we did with the chart (refers to six posters I used in order to mediate each of the steps). The thing that sticks in my mind and I can say that this has been huge, is that they verbalised it, obviously internalising it, (saying) 'what have you got?', 'gather the data', 'what can you work with?' And then they extrapolate from that: I only have these 3 points, but somebody else must have 5/6 gathered points, and they can now predict or infer from that, so they are using it. There is no doubt in my mind that the skills taught are being applied and hopefully they will continue to use those in the class. (p. 2)

His response indicates that the learners were using the systematic approach and applying it outside of the science classes as well.

In the first questionnaire most of the learners answered that they agree or agree strongly with these statements:

Questionnaire statements	Strongly disagree	Disagree	Un-decided	agree	Strongly Agree	Sum
1. A plan is a useful tool to solve any task			2	5	4	9/11
2. In order to solve a task I first define the problem			2	3	6	9/11
3. I never check my own work by myself	3	2	2	1	3	-
4. I change my plan when it does not help me solve my problem			1	6	4	10/11
5. Usually I start working and only then I define the problem	3	3	1	2	2	-
6. I have no strategy to how to solve a problem	4	2	0	1	4	-
7. I often decide what steps I am going to take in order to reach my goal			1	5	4	9/11
8. I don't care about the rules when I solve a problem	7	2	1		1	9/11
9. I can't solve a problem by myself	3	2	2	2	2	-
10. I use my plan while I am working			1	4	6	10/11
11. I try to gather information before I solve the problem		1		4	5	9/11

Table 2. Sum Results of Questionnaire No. 1 of the Grade 6 Learners.

The learners stated that they appreciated the use of a plan, understood the different steps of the approach and indicated that they used plans when they did their work. The results indicate that some of the learners report that they do not check their work by themselves and some indicate that they cannot solve a problem on their own (statements 6 and 9). This might reflect on how dependent the learners are. One explanation may be the lack of self-confidence and low self-esteem many of the learners display, which is one of the reasons they are in the school in the first place (according to an informal conversation with the classroom teacher). It might also be a result of lacking strategies to solve problems. Yet another explanation might be that they were not asked to check their own work, and are therefore not used to doing so.

In the following lessons various aspects of the experimental planning were addressed more explicitly using exercises from selected IE Instruments, such as following instructions, comparing, classification and so on, or by using adjusted material from the textbook.

4.2.1.2 Following instructions

Conducting experiments requires accuracy and consistency, and the ability to compare results from two different experiments depends to a great extent on the fact that both are conducted in the same way (apart from one variable we change), using the same quantities and accurate measurements. The third lesson's aim was to practise 'Following instructions', which is an important ability when conducting an experiment or for following a protocol. If the preliminary conditions are not exactly the same, no one would be able to conclude anything from a set of data.

Many of the Grade 6 learners displayed impulsive behaviour, lack of concentration or unorganised ways of working, which may have interfered with their ability to produce reliable experimental results. Since I wanted to introduce and mimic laboratory work in the classroom to a certain extent, the ability to follow instructions was, in my view, an important skill to develop. Obviously the ability to follow instructions is part of everyday life as we come across all sorts of instructions at school, at work, around the house or when operating almost any device. Therefore, explaining its importance and bridging the need to 'follow instructions' to science were relatively easy tasks and learners could relate to this immediately.

I started off by giving very vague instructions on how to mix a specific solution and some of the learners asked me to be more accurate in my description. After discussing the importance of following instructions, I demonstrated the functioning of the apparatus they had on their desks and how learners should use them. I specifically introduced the measuring cylinder and mediated some of the rules one should follow in a science laboratory, even though our science laboratory in the classroom context was a simple one and not so well equipped. Then I changed the original instructions and gave them more accurate instructions specifying the volume of water they should use and amount of juice powder. They experimented with mixing various solutions and were able to compare them.

This activity was followed up by one of the first exercises of the IE instrument *Instructions* (see Appendix C for examples), in which the learners had to read the instruction and to carry it out. The tasks use verbal and figural modalities, and characterise the relationships between geometric figures and their location within a specific frame [(Feuerstein 1980) p. 223-224]. According to Feuerstein, in these tasks the instructions are presented in a way so as to compel planning behaviour and to counteract impulsive responses, and feedback is a built-in part of the task through comparison between the instruction issued and the motor performance [(Feuerstein 1980) p. 221]. Most of the learners coped very well with this task, describing and actively producing drawings according to the instruction they had been given. Nevertheless, some of the learners manifested left/right confusion (**Sa**), wrong description of location (the circle is to the left of the *corner* instead of *rectangle*-**Tm**) or partial reading of the instruction that led to an incomplete task (**Nig**). All of these are typical errors according to Feuerstein [(Feuerstein 1980) p. 225], but since only a few of the learners manifested them, and since I had a limited time frame, I decided to move on, knowing that it was possible to address these typical errors with further practice.

In the last activity of the lesson on instructions, learners had to write down their own instructions on to 'how to prepare tea' from a given worksheet that I adopted from the science book [(Cadle *et al.* 1995b) p. 4], which included pictures of different steps of tea preparation, not necessarily in the right order. I found that all of the learners were capable of writing instructions, though some of the learners used very concrete thinking; for example, **Nig** testified that he wrote the instructions down while watching his mother preparing some tea, while others (for example **Sa**, **K**, **Col**) wrote the instructions 'from their head'. **Sa** described the activity of preparing tea as follows: 'it's a second habit to us to make tea so it was difficult to think what are the steps'. **Cht** was one of the few learners who actually used the page I gave and described herself looking at the pictures and arranging them first, and then she added:' I started from 'what are the rules'? To be systematic… I checked my work - looked at the pictures and thought if it says exactly as it looks like…'

At the end of the lesson I asked why was it important for instructions to be clear.

Nig replied: 'if it's not (clear) - we won't be in the same point you want. If everybody follows the same instructions, everybody will get to the same results'.

To the question: 'What was the purpose of these activities?', the learners replied:

Chp: 'getting the right adjustment…'

K: 'using the measurements accurately…'

Sa: 'to practise the systematical approach…'

Nig: 'how we listen, how accurate we are…'

Cht: 'to see if we are concentrated…'

These answers reflect on different ideas and skills we used in this particular lesson as the learners perceived them.

Following instructions plays an important role in any task one approaches, but since the learners were used to getting instructions and to following them, spending one lesson was sufficient to stress its importance and to practise it. Nevertheless, as I mentioned before, I could have introduced some more exercises to the few who struggled with some of the typical errors of the instrument, and help them restrain their impulsiveness as they worked, so that they could be more efficient and accurate.

4.2.1.3 Measuring

When conducting experiment learners often need to measure quantities and use units of different dimensions. The aim of this lesson was to familiarise them with as many dimensions as possible and to link the dimensions with the appropriate units, as well as to practise measuring volume and weights. When I asked the learners to give an example for one dimension and what it measures, the learners mentioned different units from all aspects in life as well as different dimensions. A few examples of the dimensions mentioned are: level of lake water, blood sugar levels, distance and depth; and the units the learners mentioned were thumbs, fingers and arms, gallon, °F and °C, feet, yards, inch, mile, km, etc. Learners actively participated and all of them contributed to this discussion. Although most of the learners were familiar with different dimensions and units, most of them had not experienced measuring using laboratory equipment like a measuring cylinder and scales that I brought from the University's student laboratory.

Using the equipment elicited excitement and all of them were very actively involved. Learners kept practising measuring using the laboratory equipment throughout the first half of the term whenever we performed experiments.

4.2.1.4 Comparative Behaviour

Comparative behaviour, according to Feuerstein, is a mental abbreviation of a motor process in which two elements are superimposed, one on the other, in order to find the points they share and the way they differ. Inducing comparison initially involves making the individual perceive and focus on two or more objects or events [(Hoffman and Feuerstein 1988b) p. 1-2]. Comparative behaviour plays an important role in almost every decision taken and in many tasks, including science tasks; for example, when comparing two experiments by looking for similarities and differences, which is an essential phase in data analysis.

I dedicated two lessons to practising and using comparisons in science. I started by using the first few exercises of the IE instrument *Comparisons* (see Appendix C for examples) and learners had to find the similarities and differences between pictures of objects and people. After completing the task, we discussed each frame and mentioned a number of parameters that objects can differ in, for example, size, orientation, colour, shape, texture, smell, taste, etc. and the fact that not all parameters are relevant to all the things we compare. Learners had to state what was common between objects that they compared. Some learners could generalise immediately saying that 'both are fruits', 'both are types of transportation', 'they both have the same face', etc. Other learners struggled finding the main similarities between the pictures, giving more concrete answers such as 'both (vehicles) have wheels'; 'both (fruits) have stems'. The same phenomenon happened when describing differences, either stating more abstract characteristics such as ‘a car is faster’ or 'a bicycle is slower' or more concrete characteristics like 'the car has a motor' and 'the bicycle has pedals'. This reflects on the learners' ability to identify the main difference or common parameter between objects, and their ability to generalise by observing the object as a whole.

In the following task the learners had to compare two solutions they prepared according to instructions I gave, and had to find as many parameters as possible when looking for similarities and differences. Learners had to give an example of one parameter and indicate if it was similar or different. We ended up with a table such as Table 3, which describes the two solutions.

Parameter	A	B	Same	Different
Amount of water in ml.	100	100	√	
Water level in the beaker	Until 100 ml	Until 100 ml	√	
Shape and Size of container	Beaker	Beaker	√	
Amount of juice powder in teaspoons.	1	2		√
Type of powder	'Clifton'	'Clifton'	√	
Colour	Light orange	Darker orange		√
Smell	Less strong	Stronger		√
Taste	Less sweet	More sweet		√

Table 3. Description of Two Juice Solutions in terms of Similarities and Differences

In this task learners observed more parameters than I expected, and some also described the link between the parameters they indicated and the relationship between the solutions. For example:

Cht: 'the colour will be different: light orange and darker orange'.

Dm: '100 ml of water. Amount of water. The same'… 'The same juice - the same powder'.

The learners completed a questionnaire about comparative behaviour; many of the learners agreed or strongly agreed on:

- I will be able to use comparisons in other classes. (8/11)
- I think I know how to use comparisons in science. (10/11)
- When I compare, I look for what is the same and what is different. (10/11)
- I automatically make comparisons when I work. (7/11)
- It is very hard to compare solutions. (7/11 disagreed or strongly disagreed)

These comments suggest that many of the learners felt comfortable with their ability to compare and they also manifested an understanding of what comparison meant.

In the next lesson I mediated the usage of the Venn diagram as a way to organise information concerning similarities and differences between things. To demonstrate the usage of the Venn diagram, we used the information on the solutions from Table 2 from the previous lesson. After one or two examples the learners understood it and helped me finish the entire comparison. Then they had to find as many parameters as possible and use the Venn diagram to organise the information when comparing two creatures I adopted from Odyssey programme (see example in Appendix B). Again, learners observed a lot more similarities and differences than I expected and manifested a full understanding of the technique.

In the third quiz a week later they had to organise information in a table into the Venn diagram and 8/11 applied it successfully. In the last quiz, 4 weeks later, learners had to compare a leopard and a giraffe using the Venn diagram. All the learners (11) successfully used the Venn diagram, either describing the animals on a more concrete level, such as long/short neck/legs, etc. or writing more abstract parameters such as herbivore/carnivore, etc. (A few examples are provided in Appendix H).

It was not surprising that the learners displayed adequate abilities to compare, since this ability is known to be 'the most elementary building block of rational thinking and therefore a primary condition for any cognitive process' [(Feuerstein 1980) p. 163]. However, I felt that since we practised it explicitly, it was easier for the learners to adopt the new concept of the Venn diagram as well as to increase the number of parameters they mentioned when they compared different things.

4.2.1.5 Factors

I dedicated the next lesson to mediating the concept of controlling variables, which I referred to as 'factors'. In order to test systematically the impact of one specific factor on a specific situation, one should change this factor but keep all the other variables the same. I wanted learners to be able to identify different factors and design experiments to check their effect. In order to achieve this goal, I divided the learners into three groups, and gave them a short story to discuss and to come up with a conclusion.

> Dina and Yael were studying for their test in science. Dina was studying hard all day and went to sleep quite early, having a good night's sleep. Yael didn't study enough and went to sleep very late. Dina succeeded very well in her science test. Yael didn't succeed so well in her science test.
>
> Can you conclude from this set of facts what is necessary for success or failure in a science test?

After the learners discussed the story in groups, they said that both factors, sleep and studying, which affect success and failure in the science test as mentioned above, are important. We opened the discussion and I asked which of the two was more important. We couldn't reach agreement, so I asked how we could check. During this discussion **Cht** replied: 'you should split them up and then see which will give you the best results; not study and have a good night sleep or study and have a good night sleep'.

Then I asked if this explanation rings a bell?

Nig said: 'one aspect at a time…'

K: 'you can't use two because you won't know which is which…'

Da: 'one of the rules - use only one experiment at a time…'

I gave them another short story, this time a description of an experiment where two factors are used simultaneously (stirring and heat), so it was impossible to determine which of them caused a specific effect (faster dissolution). When they had to come to a conclusion after discussing the problem in groups, **Nig** said:

'Miss, you can't say because she (Dina) used both at the same time, so we don't know…'

K suggested to use 'hot water and salt, cold water and salt and leave them to see in which of the two it dissolves faster...'

I felt that it was a good lesson even though the topic was not easy for the learners. They answered a questionnaire regarding this topic, which revealed the following results:

- I will be able to identify factors in different experiments. 9/11 (agreed or strongly agreed).
- I think I know how to use factors in science. 8/11 (agreed or strongly agreed).
- When I use any factor I use only one at a time. 9/11 (agreed or strongly agreed).

Nevertheless 6 testified that it was very hard to find factors in the experiment we have done.

To complete this picture, learners had to identify factors that can affect solubility in a quiz they answered a week later (quiz 3). 9 out of 11 found at least one factor and altogether four factors were mentioned: amount of water, amount of salt, stirring and temperature.

These findings suggest that, although this is a difficult concept to grasp, after mediation and practice, the majority of learners understood very well.

4.2.1.6 Infer

In the second half of the term I introduced the topic 'food and feeding' and the first skill I mediated was inferring. Since direct observation of some phenomena is not always possible due to technical problems like visibility, size of particles, or due to other problems, inferring from what can be observed about what cannot be directly observed can be very useful in science and in other everyday tasks. We discussed the functions that living organisms (which we referred to as 'all living things') display, such as feeding and water consumption, reproduction and movement, which can be directly observed in most cases. We also discussed other characteristics such as the ability to change and adapt, organism growth and the need for oxygen, which can be deduced from indirect observations.

Cht shared with us her evidence of movement in plants by witnessing tendrils of vines, and **Da** gave an example of flowers that open and close during the day, as well as movement of plants towards the sun.

To practise the skill learners had to help me tell the 'invisible story' (see Appendix B for example), which consisted of pictures without any text, but the plot could be understood by inference. Each learner 'read' a page, and some explained how they perceived it.

Da: 'he went to the cupboard, and put some shoes on and walked away leaving black footprints'.

Col: 'he put also some clothes'.

Teacher: How did you know?

Col: 'there are some clothes missing. One clothes hanger is empty'.

Sa: 'he put the gramophone on and danced…because of the steps…'

Although the learners successfully inferred throughout the lesson, only half of the learners who replied to questionnaire 5 agreed or strongly agreed with these statements:

- When I infer, I look for clues that help me gain meaning. (4/8 agreed or strongly agreed)
- Infer means to gain meaning indirectly. (4/8 agreed or strongly agreed)

When I tried to understand why only half of the learners could define the term 'infer', I went back to the video material and saw that I did not stress the link between the term and the operation, which may partly explain the questionnaire's results. Nevertheless, in the last lesson, when challenged to give a definition of what infer means, **K** replied: 'its when you got evidence but you don't see the thing, you don't see the person, but what he left behind, as it is with a bird's nest, you don't see the birds but what they left behind…' (lesson 16).

Col: 'when you infer it is like archaeologist that looks at a skeleton and says how old it is…' (lesson 16).

4.2.1.7 Classification

Classification is based on successful comparisons, differentiation and discrimination [(Feuerstein 1980) p. 175]. In order to mediate classification I started by using p. 15 as an exercise from the IE instrument *Categorization* (see Appendix C for examples). The learners had to classify circles according to two criteria such as size and colour. Since this was quite easy for the learners, I bridged it into everyday situations such as the supermarket classification of products and the household classification of laundry and groceries.

I mediated the principles of classification in biology by introducing the learners to some knowledge of systematic classification, which classifies organisms into five kingdoms. The five kingdoms can be sub-classified into phylum, class, order, family, etc. and I simplified the principle of each classification. The learners had to classify the animals [from *Categorization,* (Hoffman and Feuerstein 1988a) p. 13] according to a linear diagram I provided for them (see Appendix C for examples) by using the number of spaces available in the diagram as well as other clues to complete it. The learners also had to complete tasks in which they had to classify animals according to their class (such as mammals, birds, reptiles) and vegetables according to the part they comprise in the plant. It is important for me to mention here that the knowledge served as examples and learners were not expected to remember the different categories (just the main kingdoms), but rather understand the principles of classification. However, a reasonably fair amount of content knowledge was transferred during these lessons and the skill of classification was stressed throughout the lessons.

Although learners were familiar with describing the similarities and differences of objects and animals, they did not perform very well when dealing with classifying using a linear diagram that they were required to build by themselves. The learners displayed what Feuerstein [(Feuerstein 1980) p. 182] referred to as a typical error, in which they sub-divided according to two principles in parallel (like both size and colour in the same sub-division), instead of first categorising according to one principle, and then according to the other.

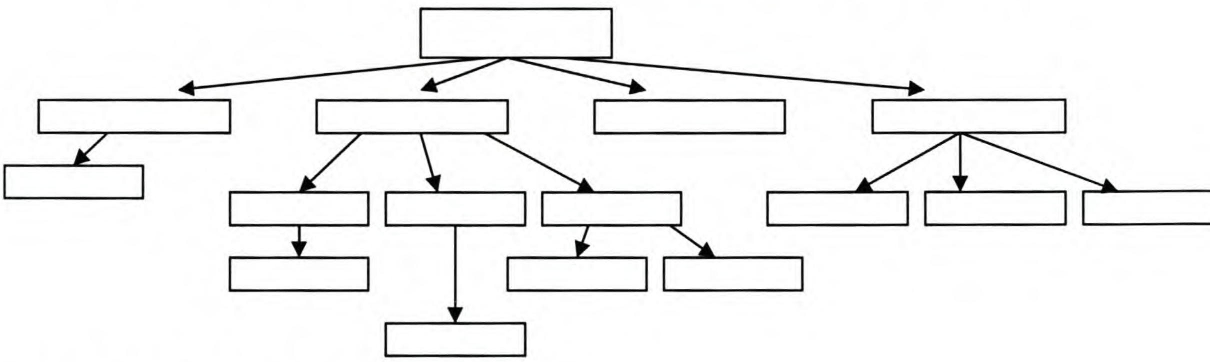
K made this type of error in the second classification of figures she did (see Appendix H).

To overcome this error I dedicated another lesson to the topic and mediated how to use the linear diagram to classify. In lesson 14 learners were divided into two groups and competed against each other; they had to classify animals according to the animals' feeding habits as opposed to classes (using the same animals but different principles). Both groups classified the animals successfully using the linear diagram to classify. Despite their success, I felt that I should have used more exercises from the IE instrument *Categorization* at the beginning to stress the principles of classification even more.

After three lessons of practical application the learners completed their last quiz in which they needed to classify a list of words according to the principles we learned such as in the following example:

Classify these organisms according to the principles we have used:

Organisms, fungi, trees, animals, herbivores, omnivores, snake, bacteria, mushroom, flowers, plants, carnivores, humans, bushes, tiger, butterfly.



(Taken from Quiz No. 4, Question No. 4)

8 out of 11 learners successfully performed this task, which required correct usage of the principles of classification, identification of the categories, systematic search, looking at the number of spaces as clues and application of knowledge.

In the open lesson we had at the end of the term, I asked the question: 'What was the most interesting thing we learned?'

Sa replied: 'classification which was a bit hard but challenging…'

Da said: 'classifying and learning about the animals…'

The classroom teacher also expressed an opinion with regard to the learners' ability to classify. The question was about my goal to teach thinking skills in science. He replied:

> There is no doubt in my mind that they clearly understood what classifying was and could take it from what was given to them as a lesson to other areas other than the content of that specific lesson and apply the issue of classifying to it. (Appendix F: Interview script 2002, p. 2)

I felt that many of the learners showed mastery of the skill, based on what had transpired in our classroom discussions, the activities we did and quizzes the learners completed. Some examples are presented in Appendix H.

4.2.2 Transfer

My second aim was to contribute to the transfer of thinking skills to other disciplines. I believe that thinking skills cannot be taught unless they are used in a specific context and different content in various disciplines can serve as vehicles to do so. For that reason I incorporated into all the lessons examples from science contexts as well as examples from other areas in life. In doing so I was trying to expose the learners to transferring the thinking skills that I had taught in one situation to different problems. One example is that, when I taught classification, I mediated the classification of shapes according to different principles such as form, size and colour, and the learners applied this by classifying vegetables according to the part of the plant they form part of, and animals according to feeding habits or according to systematic classification, as I described earlier (see p. 116-118). Since the examples we used were quite diverse and the emphasis was mainly on the skill and less on the content, it was relatively easy for the learners to apply the principles of the thinking skills to other tasks.

Many of the learners stated that they felt comfortable with the different thinking skills we learned and would be able to use them in other situations, as appeared from their response to some of the statements regarding transfer in various questionnaires:

- I will be able to use comparisons in other classes. (Q. 3) 8/11 agreed or strongly agreed.
- I believe it will be difficult to use comparisons outside school. (Q. 3) 6/11 disagreed or strongly disagreed.
- I think I know how to classify things. (Q. 6) 8/8 agreed or strongly agreed.
- No one can classify outside the classroom. (Q. 6) 6/8 disagreed or strongly disagreed.

It seemed that when learners felt confident with a specific skill, they could apply it in other situations. The classroom teacher supported this notion saying:

> So what the goal was for that day, I would say we achieved the goal of observing very well, but there was a transference or bridging to other things. I was almost sure that they immediately internalised the act of observing… (Appendix F: Interview script 2002, p. 1)
>
> …There is no doubt in my mind that they clearly understood what classifying was and could take it from what was given to them as a lesson to other areas other

> than the content of that specific lesson and apply the issue of classifying to it… (Appendix F: Interview script 2002, Appendix F: Interview script 2002, p. 2)
>
> I'm referring not only to the acquisition of the skill, but the bridging from a specific lesson to life in general, so that we would be doing maths, for example. Have you got all the rules, have you gathered all the data? That is not quite gathering data, but they are thinking along lines of gathering, so they are using a skill that was taught very recently and say, 'but you haven't got all the rules – when you do multiplication or fractions, you got to have this, this and this'. So what they're doing is they don't perhaps do gathering, but applying the skill of gathering to say: I know I need 3 of those things, but I've only got 2, I don't remember the third. (Appendix F: Interview script 2002, p. 3)
>
> I thought it (using the IE instruments to teach a skill) was excellent and I think the most significant one for me is the one I remember well, namely the Venn diagram. It came to them like THIS. They could immediately apply the knowledge gained through bridging to the science lessons that followed and followed the classification. So I would rate that as absolutely excellent. (Appendix F: Interview script 2002, p. 6)

From these quotations it is clear that the learners showed a gain in mastery of thinking skills; they could apply them in science and they could also apply them to a certain extent in other disciplines. So, although I mainly used examples from science, I laid the grounds for using these skills in other disciplines as well.

4.2.3 Special Needs

The third aim of this project was to choose activities which integrate thinking skills and present content in such a way that will be suitable for the learners' needs, and allow them to develop and progress in spite of the problems and difficulties they manifest, such as distractibility, a passive approach to learning, ineffective learning and memory, poor self-concept, impulsive behaviour and low motivation to succeed at academic tasks, which are common among learners with special needs [(Ormrod 1995) p.193-194]. For this purpose I chose IE instruments, which are designed to deal with these kinds of problems. I integrated exercises into the lessons I designed in such a way that the activities were very diverse and engaging, leading to greater co-operation and anticipation on the part of the learners.

I taught the learners twice a week for a period of an hour for one full term, so my expectations of observing micro-changes were quite limited. However, many of the learners remembered even the smallest detail I taught them from lesson to lesson and they were able to apply the thinking skills sometimes weeks after being taught, and throughout the term. Personally, I think that the way the lessons were designed, and the activities I chose, were suitable for their needs. The classroom teacher reflected on the knowledge that was gained, saying:

> I think, for example, people like **Nig** come to mind. He will tell you when a solution happens in detail, in very broken English he will share with you that there has been an acquisition of knowledge. He can apply that, whether he is making tea or not, with or without sugar. So definitely, again for most of the children, with one or two exceptions, but the most, there was an acquisition/acquiring of knowledge. And they will take it wherever they go. I think that has happened because of the way you went about it, the way that you structured the lesson, whether they were allowed to get hands-on experience and use the experiments to arrive at the conclusions that you have seen. (Appendix F: Interview script 2002, p. 3)

He also relates to their specific problems when describing how the learners engaged in different activities we did in the class, saying:

> Then you have children with writing difficulties/problems, I found the lesson sheets/notes weren't too lengthy, too cumbersome in terms of their ability to do the work – in other words, there wasn't much on a worksheet that would overpower (them by saying) – 'I cannot do this…', feel traumatized by a mass of stuff. It was sufficiently scanty to keep them focused. Because remember, our biggest problem here is focus and throughout we saw that the children, once they got involved individually or in their groups, were able to maintain the focus which is a major thing for us here. If you can hold the kid's attention for 3 to 4 to 5 minutes, you have achieved enormously… In this instance, the video material will show you, the animated way they got involved and they did their work sheets and surely enjoyed it. So it was very pleasing for me to see that children with reading and spelling problems getting involved with a given worksheet. (Appendix F: Interview script 2002, p. 5)
>
> I think for most of the children… I would say, it was excellent. Never forget that we're not dealing with your average child in a normal mainstream school. You've got exceptional children here with all sorts of emotional, social and scholastic problems. (Appendix F: Interview script 2002, p. 5)

In order to increase even more the micro-changes in learners' behaviour and to help the learners to overcome some of their other problems as well, I think that more exercises from the *OOD, Comparison and Categorization* instruments might have been used. The typical problems the learners' display might be overcome by intense use of IE instruments, as shown in the literature review. Together with this, I feel that the intervention programme as it stands was suitable for my learners' needs, taking into consideration my time frame and my other aims in the programme, which I have already referred to above.

4.2.4 Joy and Engagement

The last two aims of the study are closely linked and they were: to increase student engagement in the science classroom and to influence the classroom learning environment. I strongly believe that my abilities as a science teacher are also measured by my success in sharing my love and passion for nature and therefore to the subject matter of science. I designed all my lessons bearing in mind that enjoyment and fun are part of a good learning experience.

The content of the first half of the term dealt with solutions and solubility, and learners experienced laboratory-like experiments. The content of the second half of the term dealt with 'food and feeding' and I tried to expose the learners to some field-work by organising three educational outings: 2 outings (lessons 10 and 15) to the Rondebosch Common and one to Cape Town aquarium.

In the first outing to Rondebosch Common learners had to collect and record all the organisms they could find. We looked at the organisms, discussing their habitats and other characteristics such as colours as warning signals and we tried to relate each organism to its class using guidebooks.

In the second outing we experimented outside, trying to determine the feeding habits of animals, which learners had captured on the Rondebosch Common, by introducing them to different kinds of food as a variable. Learners had to write down where they captured the animal, their observations of it, and their conclusions about its feeding habits.

In the outing to the Cape Town aquarium learners listened to an interactive lesson given by one of the aquarium teachers about the Indian and Atlantic oceans and the organisms living in them. I asked the teacher to speak about the feeding habits of some of the organisms and by doing so linking her lesson to our science class content. Then the learners had to identify organisms in the display according to descriptions I gave them as riddles (see Appendix B).

These activities left a great impression on the learners throughout the term, which they expressed verbally on different occasions in the questionnaires that they completed and in the open discussion we had at the last lesson. To the question: 'How was it to learn science?' some said:

K: 'Exciting, learning about different experiences and going to the 'Common' - it was fun it wasn't all work, work, work, it was also fun… especially the experiments in the Common, when we practised the diagram [referring to the Venn diagram], and had competitions…'

Ter: 'when we went to the Common and experienced with the insects, the aquarium was interesting…'

Sa: 'I enjoyed science, but sometimes it was boring - learning about factors - I didn't really understand it… it was hard…'

Dm: 'Experimenting and learning about the insects…'

Sa: '… also the invisible story…'

Da: ' …the quiz from the aquarium'

Chp: …the Common was nice…

Nig: 'For me it was very interesting, it was something new…'

The classroom teacher referred to the outings:

> …(L)ook at observing and we look at the outings that we had, we may have had something very specific on a worksheet which was an act of observing, but that led to other things, observing as well. So what the goal was for that day, I would say we achieved the goal of observing very well, but there was a transference or bridging to other things. I was almost sure that they immediately internalised the act of observing. The activity was a good thing for them, they went out there, enjoyed the outdoors, enjoyed the activity of collecting (the animals) and then observing. (Appendix F: Interview script 2002, p. 2)
>
> I would say what they learned there would have been an extension of what was learned in the classroom first. The short answer is yes – learning occurred and I think on the first outing, they saw it more as a fun-thing than a learning-thing.

> Learning occurred, there is no doubt in my mind that learning did occur and would have been an extension of the stuff that was done in the classroom. (Appendix F: Interview script 2002, p. 4)

From my observations throughout the term the learners were enthusiastic to see me and to participate in the lessons.

I also received some personal gestures from **Sa,** who gave me two different cards in which she thanked me for teaching her; **Col** wrote on the back of one questionnaire: 'I really, really like to work with you Ms'; and **Nig** wrote to me: 'thank you miss Galyam'.

Apart from the bond that was formed between us (teacher and learners), they developed good attitudes towards the subject, and at the end of the term four of them were about to start Biology junior classes at the aquarium.

The classroom teacher confirmed this, indicating:

> It was interesting for them, it certainly was. Again if we would go back to your video material, to see how excited they got about certain of the lessons, how animated they became, how they suddenly enjoyed, and as I've told you several times, it's approaching your arrival time and already they're telling me that you're coming. You're about to, you're here...So, yes I think...(Appendix F: Interview script 2002, p. 4)
>
> Just that they suddenly enjoyed the content as presented. I think throughout, this is the one thing that can be said. That can be highlighted throughout that there was participation and that participation was coupled with that 'I enjoyed myself in this class'. With the one or two obvious exceptions – there will always be one or two exceptions...(Appendix F: Interview script 2002, p. 4)
>
> *Has the programme contributed to their attitude towards science subject matter?*
>
> I have no doubt that as a direct result of what you did, those children, at least three to four of them, three definitely would get involved and are going to get involved with the aquarium, the junior biologists programme and, although they will not be at this school next year, I certainly have every reason to believe that they are going to go on and what you did for them over here contributed to their much better and keener understanding of the world of science... (Appendix F: Interview script 2002, p. 6)

Another interesting finding is that, although the science content played a secondary role in this programme, most of it was understood and remembered extremely well by my learners. I find this very rewarding, since a common critique of the cognitive approach is that it consumes time and does not leave enough time for teaching content knowledge. Since the lessons were very structured, and a step-by-step approach was adopted to deal with different aspects of the scientific method, complex concepts such as controlling variables, formulating hypotheses etc., were understood by most of my learners. The classroom teacher also indicated that the amount of knowledge I mediated, as well as the learners' ability to remember it, was by far more than what he had assumed these learners could perceive.

From our interview:

> *Can you mark the amount of knowledge that was transferred? Was it a lot of knowledge, a fair amount of knowledge or was it a very little amount of knowledge compared to what you can do, let's say in one term...?*
>
> Because of the problems that these children have, contents stuff like science, biology, history and the like, doesn't play a major role in their so-called redevelopment over the 2 or 3 years that they are with us. We concentrate on self-esteem, image, literacy and numeracy and so what you are referring to now plays a secondary or 'further down the road' role. We would do less than what you covered in the same time period and actually another important aspect that is coming out of your teaching here is that when we believe that they can't cope with the quantity of material offered to them in the science class through your lesson system compared to what they are going to have to do in high school mainstream. So I'm saying, they covered more than I would have planned for the exact same lesson. The belief is that, because they've got reading and spelling difficulties, they would cope less well. And yes, that may be, but I think the way we have gone about mix of reading and experimenting hands-on shows at the end of the day that they are able to measure the content in their minds and their brains. That would then be quite significantly more than what would have been planned for on our term planner for them. We seldom get, for the 11 or 12 weeks in the term, we plan science, biology and history for that term, and we seldom get through those 11 weeks as planned for....
> You did it better than we do... (Appendix F: Interview script 2002, p. 3)

4.2.5 Communication

A very interesting personal point for me was my experience teaching in a foreign language. Despite the fact that English is taught in all schools in Israel since Grade 4, I never used English as much as I did since arriving in South Africa.

When I was designing my programme I did not want to teach the learners, mainly because of a language barrier. I believe that teachers should teach in a language which they feel confident and comfortable with, and which will enable them to draw on variety of examples from all aspects of life without considering their (in)ability to express themselves. My style of teaching includes using facial expressions, changes of voice and intonation, and mimicry, but to be able to 'perform' these I would need to be able to express myself freely.

Obviously, teaching in English affected especially the characteristics mentioned here and had an impact on my teaching style, as I observed in the video material. When I asked the classroom teacher to describe me as a teacher, he replied:

> When we first planned this term project, you wanted no teaching, because you thought that there was going to be a serious communication problem because of your own perceived inability to communicate effectively in English, and maybe one or two other factors, maybe your accent or whatever, I don't know.
> Now, having a look at that and reflecting on everything we've just spoken about in the last half or three quarters of an hour, and what we said has transpired, then you underestimated your own ability and this is the proof on video to show that you coped more than adequately with your perceived language inability and I never taught a single lesson and initially the idea was that I was going to teach and you are going to do one or two (lessons). If I'm going to put this on video, I'm saying this to you now – I encouraged you to teach all of them and you did exceptionally well. So for a teacher who thought she couldn't do it to one who has ended up with more than excellent results given all the perceived imperfections from your side, I think you did exceptionally well. Let me add, if you would ask the same question to all of the children, should we have Ms Galyam here, if I'd say No, she is not and that is my decision', they would shout me down and vote you in. Honestly, from the hearts from each of those little boys and girls that you had the privilege to spend the three months with, that we had the privilege. (Appendix F: Interview script 2002, p. 7)

So as one can see, the classroom teacher did not think my language abilities were a problem in my teaching. Nor did my learners, answering almost together ''No'' to the question whether my English was a problem for them – on the contrary. But, interestingly, to the question whether I was enthusiastic about my work, the classroom teacher said:

> I think very enthusiastic, if you carry 5 litres of water round a big place like this, etc. you've got to be reasonably enthusiastic or more... I think your enthusiasm, which could not be seen, was a direct result of your inability to communicate through the English language. That was all; you would be eager to say something, for example, and you would stumble over words or means of expressing it. If they could all speak Hebrew, I have no doubt that one would immediately see a level of enthusiasm that possibly was for any other viewer, somebody who is not in the

> know, like I was there. If you should just give this to somebody, a class of students to view, they would say that she is not very enthusiastic maybe, and that would be because of the language medium that you had to use. (Appendix F: Interview script 2002, p. 8)
>
> *How would you rank it?*
>
> I would say excellent.
>
> *Excellent? I thought you said you could see sometimes...*
>
> I would say, you can't get away from the fact that you were enthusiastic. The fact that you were not able to express it maybe as brilliantly as another English-speaking person, it is no fault of yours. I'm saying that anybody viewing the video might not see that and disagree with me, but they were not there from lesson one to see what was happening, how you went about it, what you did, how you put... We phoned/emailed and we spoke about it. (Appendix F: Interview script 2002, p. 8)

Because of specific circumstances I taught the whole programme, and learnt a lot from it. It was an amazing experience and definitely improved my personal abilities as a teacher, a mediator, curriculum designer and observer. And beyond all doubt also my English abilities. Despite the fact that my learners understood me, benefited from the programme to a great extent, I still believe, especially taking the classroom teacher comments about it, that a teacher should teach in a language she or he is fluent in, understanding all nuances and niceties of the language.

4.2.6 Mediation

Mediated Learning Experience (MLE) is a theory of learning, where the teacher, a parent or any other character in the child's life directs the child's attention to a particular object or situation, and assists him or her to interpret and gain meaning from the surrounding environment [(Feuerstein *et al.* 1981) p. 271]. Mediation, according to Feuerstein, has to include at least three main characteristics out of the twelve he mentions, namely, Intentionality, Meaning and Transcendence. According to Haywood, mediators use several quite specialised strategies or mediating mechanisms:

1. Process questioning ('how' questions) such as:

- Why do you think so?

- Tell me how you did it;
- What do you think will happen if...?

2. Bridging mainly the cognitive functions or concepts and sometimes also knowledge;
3. Challenging or requiring justifications for correct and incorrect answers;
4. Teaching about rules that should lead to the ability to generalise;
5. Emphasising order, predictability system, sequence and strategies [(Haywood 1993) p. 31-31].

Evaluation of my abilities to mediate by observing the video materials and the reflections with the classroom teacher, as well as what he said in the interview, revealed that I mediated Intentionality and Reciprocity well, as I was very enthusiastic to teach and chose intriguing tasks for the learners. I felt my learners were enthusiastic to learn: they looked forward to my lessons and responded well to the different activities I introduced. I mediated the meaning of what we were doing in science and why it was important and meaningful to them by bridging the scientific approach to everyday needs such as medication, agriculture development and industry. However, in terms of Transcendence, bridging the skills to other disciplines wasn't done enough. From what emerged from the classroom teacher's comments as well as some evidence I collected from the video material and during the lessons, I felt I could and should have bridged the skills to other learning areas and situations even more. That most likely affected the transfer of the skills to other areas of interest.

Usage of mediation requires questioning. At the beginning the classroom teacher indicated a few times that I'm not using all my opportunities to question the learners on their thoughts and ways of thinking, and by doing so depriving the learners of opportunities to grow and understand. Slowly, by reflecting on my teaching through the videotapes, I learnt to recognise those opportunities and become more aware to try and address them with one of the suggested questions, knowing that this action may increase learners' understanding and also can become second nature to me. By lesson 8 the classroom teacher indicated more and more that my abilities to clarify, ask for explanation and justifications, and mediation had improved; that I improved learner's ways of thinking and helped them gain more meaning out of the learning experience. I felt that I spent more time listening to what *they* had to say by guiding them through questions, rather than ''helping'' them answer in the right way. The classroom teacher said in our interview that:

> You listened very carefully and, as we spoke and reflected on the lessons, from lesson 1 onwards, initially there wasn't any mediating, later the mediating came more and more and played a greater role. Then I would say, yes, you did listen very well. You gave an opportunity for the learner to express what he/she wanted to express in a meaningful way. (Appendix F: Interview script 2002, p. 8-9)
>
> The mediating aspect, Dr. Worrall would tell you that you are a good mediator after two years of practice. You've been here exactly three months and we saw with the after-lesson discussions that we had that it did come in and that's the only other thing I could think of. It's not something that comes naturally. (Appendix F: Interview script 2002, p. 9)

Some say it takes a few years to become a good mediator and, although there is noticeable progress in my abilities, there is still room for improvement in this regard.

4.3 In Between Cycles of Inquiry

Based on reflections on the first cycle of inquiry, I introduced a few changes into the curriculum for the Grade 5 learners. I decided to work with Grade 5 learners in the second cycle for various reasons: (1) They are expected to develop similar thinking skills (according to the outcomes for intermediate level as specified in the Revised National Curriculum Statement) as the Grade 6 learners. (2) Being younger, their thinking skills may be less developed, especially in terms of strategies for learning effectively, which might throw light on the effectiveness of the intervention programme in developing these skills, and (3) The classroom teacher I used to work with in the previous cycle of inquiry was the same classroom teacher who taught the Grade 5 learners, which provided a similar environment for the study to take place in, and which therefore increases the validity of the study.

I tried to integrate into the lessons some of the findings learned from the first cycle of inquiry, especially those which had a positive effect on the learning of thinking skills. Below I elaborate on the changes introduced into the programme and the reasons why they were introduced.

- Since the Grade 5 learners were younger, I decided to teach fewer thinking skills during the term and rather spent more time on each skill in order to consolidate it. I chose to teach basic skills, which will be useful to the younger learners who may be less experienced, less knowledgeable and less equipped with strategies or approaches to solve tasks. I chose to mediate explicitly 'the six-step approach to planning', 'comparing' and 'classification' as useful thinking skills to problem solving. I added to this list the thinking skills 'measuring' and 'experimenting', which are important skills in science learning contexts. However, I did bear in mind that some of the complex concepts of the scientific approach, which were difficult for the Grade 6 learners, should be simplified for the younger learners, such as those related to controlling variables and the use of controls to validate data.

  I dedicated four lessons to mediating the six-step approach to planning and the learners had to apply the approach to design various experiments.

Four lessons were devoted to measuring and experimenting and an introduction to the kinetic theory concepts and knowledge were mediated.

I intended to mediate comparisons over four lessons, in which learners put into practice the basic skill of comparing and they learned how to use the continuum scale and the Venn diagram as strategies to compare and organise knowledge.

I used three lessons to mediate the principles of categorisation, using different materials as vehicles for practising it, and to teach the usage of the linear diagram as a strategy to organise and to order information according to a hierarchy, from general and abstract to specific and concrete.

- An additional change that I introduced was the integration of more exercises from the IE instruments *OOD, Comparisons and Categorization* when I mediated the relevant skills in the different lessons, as one of the ways to consolidate the basic skill before bridging takes place. The decision was taken because of a mutual feeling that the classroom teacher and I had, based on what transpired from the interview and from the data analysis, that more practice of the thinking skills before bridging is important and could enhance the learners' ability to use them effectively. The fact that the Grade 5 learners were younger made this decision even more appropriate.
- I made a mental note to pay careful attention and to focus on mediating, by using as many opportunities as possible to challenge the ways in which learners think, to pose questions and ask for justifications on correct as well as incorrect answers.
- From the data analysis of the first cycle of inquiry it emerged that the mediational aspects regarding 'Transcendence', which depends strongly on bridging, were not stressed enough in my teaching. Since one of my aims was to contribute to the transfer of the thinking skills into other disciplines, this mediational aspect was important to achieve this aim. I purposefully integrated some general examples from everyday situations as well as from science contexts, and hoped that this would affect and enhance the transfer of the skills into other disciplines.
- I made an effort to create as many group activities as possible to allow my learners to benefit from pair and group discussions.
- The changes I wanted to introduce in order to consolidate the thinking skills were time consuming, so I planned on teaching less content knowledge.

- As far as the mediating of Intentionality and Meaning were concerned, I started off by providing information about the programme. I described the lessons and the content, so that the learners would have a broad picture of where they are headed and what they should expect from each lesson. A description of the programme was presented on a poster, which contained a short description of each lesson, its activities and some pictures, and later the poster served as a source of information for the learners, as well as a point of reference when they needed it. All of these considerations informed the second cycle of inquiry, which I shall now describe.

4.4 Second Cycle of Inquiry - Case Study II

The second cycle of inquiry took place in the same private school, Pro-Ed, having the same set up as described in detail in the first cycle of inquiry.

The group I taught was 12 Grade 5 learners from mixed racial backgrounds: one black, 5 coloured and 6 white learners. After six lessons one of the learners, who was a year older than the others, was transferred to a senior group of learners, and the Grade 5 class was reduced to 11 learners and this remained so until end of the programme. The total sample of questionnaires and quizzes as well as other worksheets was therefore 12 at the beginning but changed to 11 from the 6th lesson, unless someone was absent from a particular lesson.

All the learners displayed some symptoms related to either Attention Deficit Hyperactive Disorder (ADHD) or Attention Deficit Disorder (ADD), and most of them suffered from low self-esteem. The learners' abilities were evaluated, their problems were identified and a specific intervention programme suitable for each learner's needs was put in place by the multidisciplinary team of the school (see my reference to this in chapter 3, under 'The Context of the Research', p. 79).

Learners differed in their ability to study and they displayed very different problems, some of which I could personally observe and learn about during my stay at the school. Two of the Grade 5 learners had below-average IQ levels, according to information I received from the classroom teacher; one of these learners was relatively slow and less mature than the other learners in the class. One of the learners suffered from communicational disorder due to a mouth impairment, causing him difficulties in pronunciation of words. Two of the learners came from a family situation where the parents were separated and the children were raised by the mother either with or without new partners. One of the learners suffered from severe scholastic problems affecting all subject areas, and had many sessions of remedial teaching during and after school hours. All of them come from relatively middle-class socio-economic backgrounds.

4.4.1 Introduction to Science Lessons

The learners were very excited to start learning science. They expressed this in the introductory lesson I gave before the term had started. I introduced myself, the research project and the intervention programme briefly, explaining the need to videotape the lessons, the research questionnaires and the fact that it will not affect their performance mark in science. However, I did not videotape this first lesson since I informed the learners only at that point. Therefore I do not have full citations from this lesson, but what I did do was to reflect immediately after the lesson on what had transpired and therefore can provide some impressions about it.

The learners enquired about the programme, asking if 'we were going to explode things' and run experiments. I believe that their curiosity and excitement were partly a result of what is presented as science and science experiments in movies and on the television. The image of science experiments sometimes includes explosions, bubbling liquids and smoke in a typical laboratory set-up. In my view this is a misleading representation of science that I had to alter without causing great disappointment to learner's and incorrect expectations from my lessons. I decided to approach this delicate situation by offering the kind of experience that is usually presented in the media, and then to have a discussion on science and research as I believe them to be in reality.

I mimicked the image of a science laboratory as represented in movies, by demonstrating an ''experiment''. I dropped dry ice into an Erlenmeyer and another typical bottle filled with red and blue liquids (water with food colorants), which immediately started to bubble and create ''smoke'' that came out of the bottles and flowed down to the ground.

The learners were fascinated. There was silence in the classroom for the whole period of the demonstration, while they adjusted their positions on their chairs to be able to get a better view and many of them smiled and concentrated on what was happening. When I had finished and removed my gloves, I heard expressions from learners such as 'wow' and 'cool'. After a short discussion, I revealed the ingredients of my ''experiment'' and asked them if it actually was an experiment. Almost in tandem they answered: 'No'. The demonstration served as a good way of drawing their attention and met some of their expectations, and a way to slowly break down the image some of them might have of science, without losing their enthusiasm for science.

4.4.2 Development of Thinking Skills

In this section I intend to describe the programme findings with regard to each of the five aims of this project as mentioned in the purpose of the research, under the heading research design in Chapter 3. I will start by addressing the first aim, which was to contribute to the development of science thinking skills, followed by a detailed discussion of the findings regarding my other aims. At the end I will describe issues related to mediation, which was originally not regarded as one of the project goals, but emerged as an essential unintended issue in the project.

4.4.2.1 Planning Behaviour

Having a plan to solve a specific task is a useful strategy when approaching different situations in life and when confronting scholastic problems. It may serve as a technique to improve on ineffective learning and memory, and to restrain impulsive behaviour, which are some of the problems that ADHD learners display.

Since the Grade 6 learners used the planning approach effectively to solve problems, I thought that the Grade 5 learners who are younger and less experienced may benefit from the planning approach even more. The reason was that they might possess fewer of the approaches and strategies to solve problems. Therefore, I decided to mediate the planning approach, adopted from IE instrument, *Organisation of Dots* (*OOD*), which consists of six steps, with this group of learners as well:

1. Define your goal.
2. Look at what is given - gathering data.
3. Decide on a strategy.
4. Establish the rules or parameters.
5. Decide on the starting point.
6. Check whether the objective has been achieved - check your work. [(Hoffman and Feuerstein 1988c) p. 18]

I mediated the six-step approach to planning using a simple problem like preparing lunch for my siblings, because the situation is taken from everyday life and I was sure that all the learners would be familiar with it. The learners were acquainted with the situation and by my asking guiding questions they participated enthusiastically, suggesting ideas to help me solve the problem, which I linked to the appropriate steps of this approach. They applied the planning approach to the first exercise from *OOD,* following the steps they had just learned. They could recall the steps and give examples from the tasks we used already in the second lesson, and applied them successfully to new tasks. One example was a 'look and find' task, in which one needs to recognise specific figures or objects in very detailed pictures (I was using the book: *Witches, Ghosts & Goblins* [by (Terrio 1992)]). Learners identified the problem easily and replied to the question as to which strategy they will use by saying: 'we will search systematically' (**P**), from 'top to bottom' (**R**) or 'left to right' (**N**).

The next two lessons were dedicated to bridging the planning approach to science by applying it to designing an experiment. I used the same examples as with the Grade 6 learners, which were easy and engaging and were suitable also for the Grade 5 learners. They practised the six steps of planning by using group activities and were encouraged to discuss science-related questions such as:

Let's check which of the objects float and which sink….

Let's check which of the solids melt faster: butter or chocolate…

Let's check which is lighter- oil or water…

Let's check if cold air rises…

Let's make a green Rhino…

Let's make solids become liquids…

I prepared a game similar to 'snakes and ladders', and which included play cards with questions the learners had to answer. Some cards were concerned with identifying different steps in the six-step approach to planning, while other cards demanded generating a hypothesis to specific problem (see Appendix I). During a variety of activities including this game, and working in groups and alone, the learners had to identify problems, gather information and generate strategies and rules related to some problems and tasks introduced to them.

Most of the Grade 5 learners (11/12) were able to identify a hypothetical question given to them. Many of the learners (11/12) mentioned different sources of information they can use, such as farmers, specialists, the Internet and books, depending on the problem involved.

They were able to think of one or more strategies to solve different problems; for example, to increase milk production learners said:

'Feed the cow more' (**J**)

'Give better care to the cows' (**Mc**)

'Suck it (the milk) faster' (**P**)

'Feed them with milk' (**R**)

'You can get it from the cow by frightening her, by chasing her' (**Tk**)

In the first quiz 8/12 learners suggested either one or two strategies concerning a hypothetical question presented to them.

We discussed the importance of controlling variables, the size of sampling and the use of control and experimental groups to validate the results, which I referred to as the rules of experimenting. However, when learners completed tasks in which they applied the approach and designed experiments, I encouraged the learners to indicate general rules which they thought will guide their work, depending on the task they were confronted with. I realised that these concepts are complex and demand a high level of understanding. Learners mentioned quite creative general rules, which they considered as important to guide their work, such as:

Be careful in general (**Sv**), of food poisoning when dealing with food products (**Mc, N**) or of getting hurt (**A, M**), and **P** suggested 'not use too much of food colorants'. When the question referred to experimenting with animals, some learners suggested 'not to hurt the animals' (**Li, Br, and R**).

Even though we did not practise the planning approach since lesson 4, in the last quiz that the learners completed, they had to help the zoo manager to create a giraffe with black and white stripes. 8/10 defined their goal, 9/10 knew where to look for information, 7 came up with a strategy to create a giraffe with black and white stripes, 6 of whom suggested different types of painting and **N** suggested injecting DNA into its skin. 6/10 indicated a relevant rule and 7/10 reported that they intend to check their work after experimenting, by looking at the outcomes and comparing it to the hypothesis.

Although the ideas generated by the Grade 5 learners were not always as creative and as diverse as the Grade 6 learners' suggestions, and even though the language they used was less accurate, the principles of the six-step approach were applied successfully to many tasks. Their performance suggests that many of the Grade 5 learners were able to use the planning approach efficiently when they needed to.

The learners were asked to answer a questionnaire regarding the planning approach, and Table 4 summarises the questionnaire's results:

Questionnaire statements	Strongly disagree	Disagree	Un-decided	Agree	Strongly Agree	Sum
1. A plan is a useful tool to solve any task			2	3	6	9/11
2. In order to solve a task I first define the problem		1	1	2	6	8/11
3. I never check my own work by myself	2	2	2	3	2	-
4. I change my plan when it does not help me solve my problem	1	2	1	3	4	7/11
5. The best way is to start working and only then define the problem	3	3	1	2	2	-
6. I have no strategy to how to solve a problem	4	3	2	1	1	7/11
7. I often decide what steps I am going to take in order to reach my goal	1			5	5	10/11
8. I don't care about the rules when I solve a problem	5	4	1	1		9/11
9. I can't solve a problem by myself	4		3	2	2	-
10. I use my plan while I am working			1	4	6	10/11
11. I try to gather information before I solve the problem	1	1	1	3	4	7/11

Table 4. Sum Results of Questionnaire No. 1 of the Grade Five Learners.

Many of the learners reported that the planning approach is a useful tool to work with and acknowledged the importance of knowing the rules that guide the work, the importance of gathering information before acting, and of being flexible when planning.

A few learners (5/11) indicated that they tend not to check their work by themselves and some (4/11) do not feel they can solve problems on their own (statements 3 and 9 in the first questionnaire).

Both of these statements have a bearing on what it means to be an independent learner and an independent problem solver. This finding may be explained by the lack of self-confidence and low self-esteem which many of the learners displayed, and might also be a result of a lack of strategies to solve problems. Yet another explanation can be that they were never requested to check their own work before.

I decided to repeat these questions in the last questionnaire I administered, hoping to see a change in this regard, since the planning approach was intended to empower learners and equip them with strategies for problem solving. 7/10 learners reported they do not check their work by themselves, while 3/10 reported they do not solve problems on their own. The Grade 6 learners manifested a similar result; however, in the first cycle I did not re-check it. It takes time for learners to internalise and thereafter manifest a habit, a strategy or a way of thinking and this programme which was introduced for one term only in both cycles may be too short a period for some skills to develop. Maybe with more time and a longer investment in the learners, an increase in their self-confidence and maybe with increasing age, this picture might improve.

With regard to transfer of the six-steps approach to planning, **R** mentioned in the open discussion that we had at the last meeting that they used the six steps of planning outside the science classroom: 'when we were going to build the volcano we were using the six steps to design it'.

The classroom teacher supported this notion in an informal conversation we had that the learners used the planning approach on several occasions, outside of science leaning contexts. He told me that they had to decorate their classroom as a Japanese hall as part of the international day held at the school and the learners worked out a plan using the six-step approach to decorate the classroom as fast and as efficiently as possible.

However, he also told me that he initiated the use of the approach. In the interview we had, he mentioned another example:

> Yesterday, to give you a classic example, the social skills teacher was in here and I happened to be here, sitting in the classroom. She broke them into two groups and she gave them two specific things to attend to. I asked her permission to just add one thing and that was: we stopped the two groups and we said to them: remember what you have learnt with Nilly, now define your goal: what does group No. 1 have to do and what does group No. 2 have to do? Now, look at the information you've got and decide on what you still need and on what strategy you are going to follow. And work out the rules. And we backed off. They knew EXACTLY what to do…she asked them to build a house and they had to nominate who is going to be the plumber, the electrician, the brick builder… The point is that the social skills teacher achieved what she wanted to, she got them all involved and they followed what they learnt in the class with you. (Appendix F: Interview script 2003, p. 2-3)

Since the classroom teacher intervened in the social skills teacher's lesson and since the learners did not apply the approach spontaneously, I cannot deduce that transfer occurred. Nevertheless, it appears that when the learners were reminded, they could use the approach very well. It might be that with time and more practice, applying the approach will occur more spontaneously.

4.4.2.2 Measuring

Part of experimenting often involves the use of laboratory equipment to measure different dimensions. I started the measurement lesson by presenting two types of bottles: a square bottle with blue liquid and a bobble bottle with red liquid in it, and asked the learners to tell in which of the bottles there was more liquid and why they thought so:

M: 'both are the same, if you push the one up then that one is wider, that is why it looks different.'

Tk: 'the blue (square bottle) got a lot more than the red one… because you can see that in the blue there is more, and to me it looks like the red one is a bit too low as if there is not enough.'

N: 'the red one (bobble bottle) has more liquid because this glass is thicker than that one (square bottle) and that one (bobble bottle) is wider than that one (square bottle).'

Br: 'they are the same, you just trying to trick us by putting it in different bottle…'

After this debate I asked the learners how can they verify which of the bottles had more liquid. Some of the learners' replies were:

P: 'you can measure it…'

M: 'there is no scientific way you can measure it because any way you measure it might be a bit more or a bit less…'

Li: 'if you take the red (bottle) and pour it into the blue (bottle), but when it's empty - you can see if it's the same or different.'

Mc: 'you can take two glasses that are exactly the same and pour both in and then you can actually see… '

The above discussion served as a good introduction to mediate ways of measuring, measurement equipment and units of various dimensions. I asked the learners to think of one example of a unit and what it measures, and prepared a list of all units and dimensions the learners mentioned, such as length, weight, temperature, pressure, volume, time, velocity, distance, etc.

We discussed how many grams in 1 kg and how many Coca-Cola cans in one bottle. The answers to these questions were not obvious to all learners and the list of units they came up appeared to be very limited. I spent a relatively long time trying to consolidate this type of knowledge, since for some of the learners it was their first experience in dealing with units and dimensions. The vocabulary was not clear to some of them; for example, they confused temperature with pressure and what each measures.

These findings suggest a lack of background knowledge on the subject, which may confirm my feelings that, although the learners were only one year younger than the previous group, they were a lot less knowledgeable than the one-year difference might suggest.

To give all learners the opportunity to practice measuring by using the basic equipment I brought from the University student laboratory, I set up a room with 5 stations and divided the class into groups of 2-3 learners. Each group measured the mass of different objects on scales, temperature of ice water and boiling water using a thermometer, and their own body temperature using a clinical thermometer. Using the measuring cylinder, they measured volume and compared the appearance of 100 ml of water in differently shaped bottles. They also measured their own height and mass.

In addition to practising measuring, I mediated the usage of a continuum scale, using their results from the previous lesson where they measured the mass of a teaspoon of sugar. This served as a trigger to speak about the accuracy of different pieces of measuring equipment, for example, the use of a teaspoon as opposed to scales. Also, learners had to build their own hydrometer from straw and clay, and they measured the density of three liquids: oil, water and glycerine. The learners had to place them on the continuum scale based on the results obtained. As a parallel activity I mediated some of the content of phases of matter to serve as a suitable context for the development of these skills.

After two lessons they answered a questionnaire on measuring and matter. Table No. 5 summarises the questionnaire's results:

Questionnaire statements	Strongly disagree	Disagree	Un-decided	agree	Strongly agree	Sum
1. When I measure 100 ml of water with a measuring cylinder it will always give the same amount			2	4	6	10/12
2 .The use of teaspoons are a very accurate way to measure amounts of sugar	3	5		2	2	8/12
3. I feel that I am now better able to measure volume, mass, height and temperature		1	4	3	4	7/12
4. I feel I have practised the measuring different things in the last lessons			2	2	8	10/12
5. Matter can be found in three states: solid, liquid and gas	3			1	8	9/12
6. Measuring accurately is important when experimenting	1	1	2	2	6	8/12
7. A continuum Scale is an instrument where we place an item on a scale between two extremes	1		2	4	5	9/12
8. It isn't necessary to measure accurate amounts when experimenting	4	3	2	2	1	7/12
9. 100 ml of water will be the same amount even if put in different containers	1		3	2	6	8/12

Table 5: Sum Results of Questionnaire No. 2 of the Grade Five Learners.

These results suggest that many of the learners felt that they practised measuring different dimensions and understood how accurate laboratory equipment was in measuring, as opposed to less accurate ways of measuring using household equipment such as spoons, cups, etc. (Statements 1, 2, 3, 4, 6, 8). Learners (9/12) also indicated that they agree with the definition of what a continuum scale is.

Although the learners practised measuring the same amount of liquid and poured it into different containers, when commenting on this in statement No. 9. some (5) were still confused about it. According to Piaget, the concrete operational stage, which includes the development of liquid conservation among others, should be fully developed between the ages 6-7 and 11-12 [(Ormrod 1995) p. 40-43]. This might explain why, although the Grade 5 learners observed the principle related to conservation of liquid, some of the learners had not developed a full understanding of it yet.

4.4.2.3 Comparative Behaviour

Comparative behaviour, according to Feuerstein, is a mental abbreviation of a motor process in which two elements are superimposed in order to find the points they share and the way they differ. Inducing comparison initially involves making the individual perceive and focus on two or more objects or events [(Hoffman and Feuerstein 1988b) p.1-2].

I started mediating comparisons by challenging the learners to find 6 differences between two mirror pictures. They described what they had to do in this specific task and how they did it. Then, I also mediated the basics of comparisons, where they had to draw a relationship between two elements, while choosing relevant criteria in each element in order to discriminate between them. They applied the thinking skill by comparing the classroom teacher and myself, finding as many dimensions for comparison as possible, and together we defined each of the criteria they had to use. They also worked in groups to find similarities and differences between solids and liquids.

Tk said that the movement of the particles is different. 'In solids the particles cannot move much and in liquids they move more freely'.

A said, 'both are made of particles.'

Li said, 'both can change into gas depending on the temperature.'

To practise this more systematically, I used the IE instrument *Comparisons*. I realised many of the learners struggled when comparing two pictures, making typical errors according to Feuerstein, by either over-generalising, saying that what is common to a girl and a boy is that they are made out of matter (instead of that both are humans or people, for example), or under-generalising (which is too exclusive, according to (Hoffman and Feuerstein 1988b) p. 12-13), saying, for example, both have a heart.

Although being able to compare is a relatively spontaneous behaviour, for many people it is limited to their most basic needs, which are not necessarily those that are relevant to academic achievements [(Hoffman and Feuerstein 1988b) p.2]. I dedicated 4 lessons to consolidating this skill, introducing some exercises from the IE instrument *Comparisons*, working in groups and individually. Together we built a linear diagram of how members of a family can be classified according to female/male parameters. These can be further classified as humans, mammals, vertebrates, living things and matter, with the result that the learners were able to see that when they compare a dog and a human being, mammals is the closest group both fit into [also adapted from (Hoffman and Feuerstein 1988b) p. 13].

This activity helped many of the learners to focus better and apply comparisons successfully in another exercise from the IE instrument *Comparisons*. One example of a successful application was that the learners had to define what was common between two pictures of the same boy; one with opened eyes and the other with closed eyes. **P** explained to **R** why his answer 'the same boy' is better than R's answer: 'both are smiling' saying: 'there are a lot of tiny bits that look the same that are common but they [referring to the faces] look like exactly the same face and this is the big [common] one'. When the learners compared two pictures of apples, in which one was small and the other one big, **J** said that the main common thing between the apples is 'both the big apple and a small apple have the same taste'. **Tk** did not agree with **J** saying: 'I don't agree because what is common about them is that they are both the same fruit' and **R** added: 'they are both apples'.

In the following activity, adopted from the same instrument [(Hoffman and Feuerstein 1988b) p. 2], the learners had to ‘‘fix’’ a wrong comparison such as:

'A bird has wings and a fish has gills'

Working out why the comparison is wrong, using a different comparison between **A** and myself, such as: 'I'm tall and he has black hair', the learners arrived at two possible answers:

J said: 'change gills into fins'

Li: 'a bird has wings and a fish has fins.'

Br: 'a bird has lungs and a fish has gills.'

R rationalised it by saying: 'in the 'bird has wings and a fish has gills' you compare two things that do not relate to each other: the wings and the gills'.

Still, **Tk,** for example, offered to fix the comparison by saying: 'birds don't have gills but fish do'. Here I mediated that she can use a negative statement like she did, but she can also compare the function of the body part, taking it to a higher level.

In the third questionnaire they had to ''fix'' a similar problem:

Men have hands : birds have a beak.

9/11 succeeded in this task (4 changed the hands to a mouth, 5 changed the beak to wings).

In the same questionnaire many of the learners responded similarly to the statements related to comparisons:

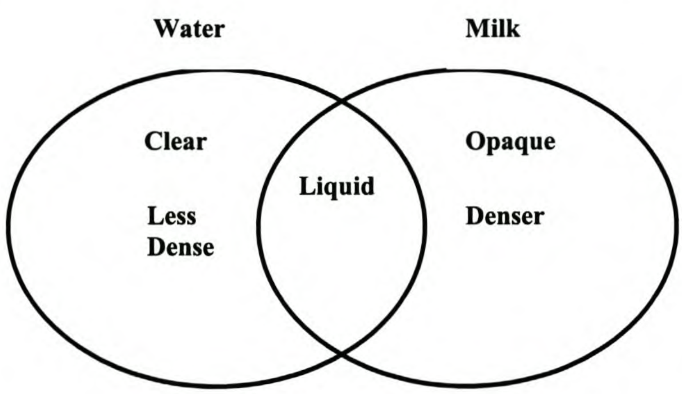
- When we compare, we draw relationships between two things, like objects, people, situations… (9/11 agreed or strongly agreed).
- When we compare we only look for differences. (8/11 disagreed or strongly disagreed).
- When I compare, I look for what is similar and what is different. (only 8 learners replied to this statement, 6 of whom agreed or strongly agreed, due to a technical problem. Since I changed the questionnaire from one lesson to another, adding statements or changing them, one row of the faces which were used to indicate how strong the learners agreed or not with the statement, was inadvertently removed, leaving an empty space before the statement (see Appendix E). Although I explained this in the class before they completed the questionnaire, only 8/11 responded to this statement either by writing yes/no answer or by drawing smiles themselves).

As part of this skill I wanted to mediate the use of the Venn diagram. First the learners compared milk and water, mentioning as many differences as possible, which we organised in a table like this:

	Water	**Milk**
Transparency	Clear	Opaque
Density	Less dense	Denser
Can get spoiled	No	Yes
Can change into solid	Yes	Yes
Liquid	Yes	Yes
Contain substances	No	Yes
Need work to get it?	Pump it into home	Milk the cow
How can you find in nature?	Springs	In side a cow

Table 6: Milk and Water Comparison using Various Parameters.

Then I mediated the use of the Venn diagram, and they helped me fill it in, comparing the same liquids.



The learners had to use the Venn diagram when they compared the same two creatures (ONO and APA) from the Odyssey programme, in which they applied it successfully; some of the pairs of learners working together found as many as 14 differences and similarities (see Appendix J). They also used the Venn diagram as a strategy to compare solids and gases in the third questionnaire, where 7/11 applied it correctly.

In the MTN Science Centre they had to compare a rocket that they used in the classroom made out of a balloon and a button to the MTN Centre's rocket made out of a plastic bottle and compressed air. 8/11 learners did this correctly, for example:
Li mentioned differences such as bottle vs. balloon, fast vs. slow, and wrote that both use air.
Br mentioned differences such as compressor vs. lungs, plastic vs. rubber, and also wrote that both are made of matter, can fly and use air.

At the beginning of the lessons in which I taught *comparisons,* the learners struggled to compare properly, either over-generalising or under-generalising, having difficulties comparing on the basis of the same parameter. Eventually many of them compared successfully, applying the strategies of the Venn diagram and the continuum scale.

4.4.2.4 Classification

Classification can be very useful to organise new as well as known information into groups, which in turn requires less memory storage and can be handled easily.
When we classify items into groups, we use the similarities to group them and use their differences to sub-divide them again. Classification depends on the task and the variety of parameters can lead to different results in terms of grouping.

I used three lessons to mediate classification, based on my experience with the previous group and knowing the learner's ability and competence. I dedicated two lessons to practising classification of very simple examples and a third lesson to bridge it to science.

I chose to mediate the principles of classification using the cover page of the IE instrument *Categorization* [from (Hoffman and Feuerstein 1988a)] and asked the learners to describe the circles they see (see Appendix C).
J said some of them are black and some are white.
Tk said some were big and some small.
M said: 'they are grouping them… [I asked according to what and he replied] size and colour'.

P said: ' if you look at it, there are big and small circles here [left] and here [right] and they go up like gas and they mix together'.

I summarised the various aspects that the learners mentioned as well as the different perspectives from top to bottom, such as grouping according to size and colour and from bottom to top where the circles mix. The link to particles and phases of matter was also discussed and appreciated.

At one stage **A** commented about the picture: 'this is racism because all the blacks are in this side [left] and all the whites are in this side [right]. Racism is a significant issue in South African history and in the development of this society, and the fact that a black kid ['coloured' according to the apartheid classification) mentioned it was not surprising at all. This comment could serve as a good introduction for a subsequent lesson regarding classification in a historical or social context. However, since I was dealing with science content, I explained how important the ability to classify is, but also that it could be used to discriminate against people according to their colour or their origin and that would be wrong.

I followed this activity by mediating the steps of classification, namely comparing and grouping through a task adopted from my IE trainer (see Appendix C). In the first task one is required to find a picture of a cow that corresponds best with a given picture, while in the second task one needs to state which of the tools (4 pliers and one pruning shears) do not belong.

The learners could explain how they solved the first and the second tasks, describing their way of thinking. For example:

Br: 'you looked at each cow's pattern as you go along and you look if it was the same as the first cow's pattern, and the closest one is the one you choose'.

I asked what was the name of this process and **N** answered 'Comparing'.

Regarding the tools, **P** said that the one that does not belong is the one that does not have a spring, and got a clip at the bottom, and **Sv** regarded their function, saying that all are plumbing tools whereas this one is a gardening tool. I was surprised to discover that a few learners were not familiar with the tools, nor with their functions, which I assumed should have been part of the background knowledge that Grade 5 learners should have.

At the end of the lesson I had a discussion with the classroom teacher about the learners' lack of basic knowledge, in which he confirmed my feelings and impression that some of the learners manifested less knowledge than expected at their age.

I used the second unit of the IE instrument to mediate systematically the principles of categorisation and made an effort to keep the knowledge relevant and easy so that the learners would be able to practise the skill first. Many learners participated actively and the tasks were simple and engaging. They had to label the group members, state the principle of classification, and describe the members that belong to that group. 7/11 were successful in classifying a novel exercise from the IE instrument, also using the linear diagram to illustrate it.

In the second lesson **P** spontaneously related the activity to his personal life, which indicates internalising the principles of the skill and transferring them to other situations in life, by classifying his toys into 'the animals, the humans…'. Other learners were able to give examples of occasions where they were using classification. For example:
Sv said: 'you sort apples in a fruit factory according to their taste or colour or size…'
Li mentioned that she also grouped her games according to their place.
R told us that in his house the builders are busy constructing and they sort the garbage according to sand, cement, broken bricks and tiles.

I used an exercise from page 16 of the instrument *Categorization*, which contains pictures of various types of transportation and the learners worked in groups, dividing types of transportation into categories using the linear diagram. They used the transport medium of use (air, land and sea) as a principle, and some also sub-divided them according to their function (military, public or recreation), manifesting adequate use of the skill. Learners were invited to the board to illustrate their linear diagram. We compared the different diagrams and discussed the sub-divisions.

The learners had to apply the principles of classification in a science learning context in a few tasks I adopted from the year's science books and adjusted to include classification tasks [(Cadle *et al.* 1995b; Clacherty *et al.* 1998)]. The tasks required gathering new information and organising it in a hierarchical way according to parameters I specified. For example, in one task they had to divide pictures presenting the use of solid water in different situations. The learners had to discuss each case and decide if it was useful or not, using the linear diagram. In the other task the learners had to divide sources of water into human-made or natural.

In the revision lesson the learners had to use the linear diagram to classify different forms of water found in nature. The class was divided into two groups and competed against each other; however, only one group divided them correctly (see Appendix J).

Nevertheless, in the last quiz all the learners (10, one was missing) divided items according to their phase of matter and all the learners used the linear diagram correctly.

The classroom teacher mentioned on two different occasions that the learners referred to a classification he was doing on the board as a linear diagram from the science lesson – once in a phonics lesson, just after I had taught them. They had to collect as many words with the long 'e' in them, and organised them by dividing the words according to the number of letters in each word (some examples are provided in Appendix J). On a second occasion the classroom teacher was dividing fractions in maths and they recognised the way he divided them and related this to what they did in the science class. He mentioned this in the interview saying:

> In maths we used it (the linear diagram) for fractions. When we discussed fractions, what type of fractions, they came up with the notion there are two types: common and decimal fractions, and under the common fractions there are 'three legs' which would involve the mixed fractions, the proper fractions and the improper fractions, and discussions around it. But again they were following the kind of stuff that was taught to them by you in the classroom. (Appendix F: Interview script 2003, p. 3)

Many of the learners were using the linear diagram effectively and followed the principles of classification. As mentioned by the classroom teacher, it seems as if the learners could also use the principles of classification in other contexts, suggesting that transfer had occurred.

4.4.3 Transfer

The second aim of my teaching was to contribute to the transfer of thinking skills to other disciplines. To achieve this aim I taught each skill explicitly and used a variety of examples to practise it. Since I believe that skills cannot be taught in isolation, I used different content as vehicles, some of them were general examples from everyday situations, while others related to specific science content. By bridging the skills in this manner I was hoping to consolidate the principles of the skill first, which in turn might enable the learners to use it effectively when solving other problems in different disciplines. As I was describing above, in a few occasions the classroom teacher reported that the learners were using some of the skills very effectively, suggesting that transfer to other disciplines had happened, and in the interview he also made this point:

> *What changes have occurred (if they have occurred) in learners' skills level and use? Do they use them better/ the same / or worse?*
>
> OK, this group has not used them (the skills) before at all. Your presentation to them would be the first time...
> I can take it to another level- they are using it in another areas in the classroom…(Appendix F: Interview script 2003, p. 2)

At this stage in the interview the classroom teacher described the learners' use of the planning approach in the social skills context, the usage of the linear diagram in maths lessons and in the context of learning phonics, which I have already mentioned above. He concluded:

> Definitely, there is transfer and we have seen it in different areas…(Appendix F: Interview script 2003, p. 3)

The increase in IE exercises served as a good way to mediate the principle of each skill and to practise them further, and I created worksheets related to the scientific content but with an emphasis on the same skill. This strategy was also a good way to mediate knowledge from the syllabus. In this regard the classroom teacher responded to my question:

> *I have increased the usage of pages (exercises) from different IE instruments. Did it contribute to their (the learners') understanding of the skills?*

> Nilly, I think one of the reasons we had this kind of success in transfer from one discipline to another might have to do with the fact that there were more pages and use. I can't say for sure, but I think so. (Appendix F: Interview script 2003, p. 5)

From the above discussion it appears that the learners applied some of the skills I taught on three different occasions, though they did not initiate this. Since these skills were stressed for one term only, and for many it was the first time they learnt them explicitly, maybe with time they would be able to use the skills spontaneously and voluntarily. However, at this point in time I cannot say conclusively that the Grade 5 learners will be able to transfer the skills to other disciplines.

4.4.4 Special Needs

As I have mentioned before, the learners of this cycle attend this school because of specific problems. The IE instruments are known to be suitable for some of the problems that learners with special needs display (Sternberg and Bhana 1986), such as distractibility, a passive approach to learning, ineffective learning and memory, a poor self-concept, impulsive behaviour, and low motivation to succeed at academic tasks [(Ormrod 1995) p. 193-194]. The third aim of this project was to choose activities which integrate thinking skills and present content in such a way which will be suitable to meet the learners' needs, and will allow them to develop and progress in spite of the problems and difficulties they manifest. I evaluated this aim by checking the use of thinking skills and recall of knowledge throughout the term.

I asked the classroom teacher to describe this group of children and their problems to me:

> A wide range of different scholastic problems. Children with great discrepancies in verbal and non-verbal scores. We are looking at children who have emotional problems, we are looking at children who do not have the intellectual potential really to mainstream: one or two of them are way below the average – two in fact out of the 11. We are looking at children who have specific learning problems in areas of reading, spelling and maths. That's a big mixed bag of problems. We had something similar, to make the first comparison, with all the boys and girls of last year same time, but an over-all general feeling about the way you went about it this year compared to last year is to say that [pause]… Somehow I get the feeling and maybe your results will show that we were more successful with this group,

> despite them being younger. What comes into mind straight away is the mediating aspect from your teaching side of things…(Appendix F: Interview script 2003, p. 1)

The learners of this cycle were younger than the previous group and a lot less knowledgeable in terms of approaches to tasks and background knowledge; however, they manifested increasing use of the thinking skills as the term progressed, as well as increase in science content knowledge. This might suggest that the material, as it was presented to them, was suitable to their abilities. The classroom teacher supported this notion saying:

> If we look at **Tk** who clearly remembered things like solid, liquid and gas. It is incredibly difficult for her as a learner with severe problems to come through… she can snap, she knew there was something there, not always answering correctly, but she had a recall. And the recall is only a result of the way you went about the science lesson and that is the worst level… I'm sure the videos will show, with the other children, people like **A** for example that came as a real surprise to you, even yesterday there was a recall from weeks ago. I can only describe as to what happened in this classroom, science, the thinking skills, the applications of those to the content and the ability of as many of the other learners to recall and to do it so accurately…(Appendix F: Interview script 2003, p. 3

Upon answering the question as to whether the learners acquired new knowledge and if the amount of knowledge mediated in one term was suitable for these learners, the classroom teacher commented:

> Giving the nature of the learners that we have in this school - the kind of children we are dealing with, I can only say it was excellent. Because what we do is... we don't spend much time on the content. Because of the other subjects like literacy and numeracy take the priority over… But we had two of your sessions every week most of the term, and they have problems writing, they have problems reading, they have problems with recall, but they can talk more than adequately about the content they have learnt with you. They stood there [shows the wall where the poster describing the different lessons and content used to be] and went through things in front of the pictures or drawings and they were able to elaborate on the content. Was it suitable? Yes, yes, absolutely…(Appendix F: Interview script 2003, p. 3)

At the end of the fourth term, two months after I had finished teaching, the classroom teacher tested the Grade 5 learners on science material he taught them in the fourth term and on material that I taught during the third term. It was mainly a multiple-choice test, with true/false questions, testing correct use of vocabulary and a few science concepts. Since I did not mediate all the content he used, I analysed the different questions in the exam and collected the questions related to the sections I had taught. After all the exam answers had been analysed, 7/11 learners passed the exam while four failed it. Since I did not place an emphasis on the content and recall of vocabulary but rather on thinking skills, and since the classroom teacher, being a well experienced mediator had the same percentage of learners passing the exam, I was reasonably satisfied with the results.

In my lessons I placed the emphasis on the thinking skills but I compromised on mediating knowledge, which was less than what was expected in one term in mainstream schools. The balance between skills and content might be optimised by longer periods of intervention, mediating the same number of thinking skills.

4.4.5 Joy and Enjoyment

The last two aims of the project relate to increasing student engagement in science lessons and influencing the classroom learning environment. As I did in the previous phase of teaching, when I designed the lessons I took cognisance of the fact that learning must be associated with fun and enjoyment as one way of creating intrinsic motivation to learn and remember. To achieve this goal I used colourful demonstrations and experiments in science, which might elicit both excitement and provide a good learning experience. I allowed the learners to touch and experience on their own, build their own hydrometer from clay and a straw, and measure density using it. They played with ''rockets'' made out of balloons with buttons having different numbers of holes to increase and reduce airflow. I prepared games to consolidate knowledge and skills, and offered a variety of tasks to practise different skills. They had group discussions and pair work, and were challenged by interesting questions. I organised a visit to the MTN Science Centre in Cape Town, where they experienced related subject matter.

When I asked the Grade 5 learners, at the last lesson, 'how was it to learn science?' Some answered 'nice', 'cool', 'fun'…
I asked them to mention one interesting thing:

P said, 'dry ice', **M**: ' gas, solid and liquid,' **Li**: 'measuring temperature', **J**: 'the outing to the MTN', **A**: 'the phases of matter'.

The classroom teacher referred to their involvement in the interview on several occasions:

> *I handed out a lot of worksheets and we did some experiments. What do you think about them?*
>
> They (the learners) find them very enjoyable. You know that worksheets bring to mind work, and you'll see from the videos that the kids really got involved ... The signs that followed a worksheet showed it very clearly when dealing with ADHD children, that they were very well focused on the activity and got involved with the worksheet. It was a very interesting piece of paper, if you wish, that was lying in front of them...
> ... I think on both occasions [referring to both years] the experiments were very well presented and on both occasion's the kids really enjoyed it, getting involved...the kids loved it... even learners like **Tk**, who have very short attention span, would ask for more... (Appendix F: Interview script 2003, p. 4)
>
> *Were there enough experiments?*
>
> No, not nearly... I'm speaking on behalf of the children, if they could they would do experiments every single day...
> But if you were asking me if there were enough experiments to cover the material I would say, yes. (Appendix F: Interview script 2003, p. 5)
>
> *Did the programme contribute positively to their attitude towards science as a subject matter? To what extent?*
>
> Good. If they knew that Nilly is coming back to teach science they would definitely go for it. As a follow-up exercise in COGNET I asked 'in what way what you learned in Nilly's science class will help you to think about becoming a scientist?' Maybe the question was a little too difficult for them – for the most part they said: they enjoyed the class. They did not quite understand the full meaning of my question... they said they would listen to something like that, that they would get back to a science lesson next year whether it was you or me... (Appendix F: Interview script 2003, p. 6)

The classroom teacher's assessment contributes to my sense that these goals were achieved to a large extent. I believe that the Grade 5 learners found the programme enriching and interesting, as **Br** wrote to me on the last questionnaire: 'I enjoyed the science lessons, it was interesting. I thought the skills were good. Thank you very much and I will miss you. Good buy'.

Tk wrote, 'I think it's fun. I think it's good and I love Nilly…'

Z wrote, 'Nilly, I love very much and I liked your lessons…'

Li wrote that she enjoyed the lessons, and **R** wrote: 'cool… cool… cool…'

4.4.6 Mediation

Mediation, according to Feuerstein [(Feuerstein *et al.* 1981) p. 271], means emphasis and awareness of specific learning-teaching characteristics displayed by a teacher (or other caregiver) that will guide the child and enable him/her to make sense of the surrounding world. According to Haywood [(Haywood 1993)], a good mediator must possess certain strategies such as process questions, challenge justifications, teaching order, and rules and the way to bridge them in order to create a quality mediated learning experience.

After evaluating my abilities as a mediator as they emerged from the previous cycle, in this phase of teaching I tried to be aware of the coming opportunities to mediate better. Apparently, as far as Feuerstein's principles are involved, for example, Intentionality and Reciprocity, which is the enthusiasm to teach (from the teachers' side) and learn (from the learners' side), I mediated very well. According to the classroom teacher, I was very enthusiastic and gave more of myself in this cycle than in the previous one (see Appendix F: Interview script 2003 p. 3), the tasks were well chosen and the learners looked forward to my lesson. I mediated Meaning, which is the second main characteristics of good MLE, of each skill and in what ways it was useful, as well as the meaning of what we were doing in science by bridging it to everyday situations.

Bridging, or Transcendence, according to Feuerstein, is the third main characteristic of MLE, which might affect the transfer of the skill to other disciplines. Apparently there were only a few pieces of evidence of transfer having taken place as was discussed above; however, on the bridging aspect the classroom teacher commented:

> Excellent. In the beginning we spoke about it as a goal you set after some feedback from my side. I think the improvement was definitely much better than last year. You were constantly aware of the bridging. (Appendix F: Interview script 2003, p. 6)

In terms of questioning and use of opportunities to mediate, the classroom teacher replied:

> Compare it to last year, there is a significant difference in my opinion. I have no doubts in my mind that the mediation in general and across the 16-17 lessons done was a great improvement on the last year. And that when we had our feedback sessions after the lessons - the few little improvements that we wanted to make would be carried forward into the following lessons. (Appendix F: Interview script 2003, p. 8)

In my own reflections after each lesson and from the analyses of the video material, I mentioned after as many as 13 lessons that there was evidence of mediation.

This is not to suggest that I used all the opportunities to mediate, but rather that an improvement in this regard had occurred, and may explain some of the intervention's success with regard to the Grade 5 learners.

4.4.7 Summary

In this chapter I described the findings of two cycles of inquiry as I perceived them as a teacher-researcher, and which were triangulated by various methods.

The Grade 6 learners, as the findings suggest, manifested an adequate use and application of thinking skills and processes to content-free and science tasks. Also they manifested an understanding of science content knowledge. Some evidence for transfer of the thinking skills to other learning areas was reported by the classroom teacher and the learners.

It seems that the Grade 6 learners learned some content knowledge and applied thinking skills successfully, which implies the suitability of the intervention programme and the suitability of the mediated teaching approach to their needs. Apparently the adjusted science material with an emphasis on thinking skills and the IE exercises, as I presented them to the Grade 6 learners, served as a good way to consolidate the skills as well as the knowledge.

The Grade 6 learners reported that they enjoyed participating in the science programme and that they would like to continue studying science in the future.

It transpired that, although the classroom teacher and the learners coped with the level of English I used throughout the intervention programme, teaching in a foreign language could lead to possible communication problems.

In terms of mediation, the findings suggest a progressive use of mediational abilities, increase in bridging, metacognitive questioning and requests for answer justifications; however, there is still more room for improvement.

In between the cycles of inquiry I introduced some changes to the intervention programme to suit the needs of the Grade 5 learners. I reduced the number of skills I taught as well as reduced the amount of knowledge I intended to teach.

The Grade 5 learners, as the findings of the second cycle suggest, manifested an increase in use and application of thinking skills and processes on content-free and science tasks. The Grade 5 learners displayed adequate understanding and recall of science content knowledge. They could apply the principles of thinking skills taught in a science context and in other learning areas, mainly after they were reminded of them, though some evidence for transfer of thinking skills and processes was also reported.

Being younger learners and possessing fewer strategies to solve problems, their performance indicates that the intervention programme suited their special needs.

The Grade 5 learners enjoyed participating in the science programme and reported they would continue with their science studies if they could.

The findings suggest better mediation abilities from my side, manifested by successful bridging, provision of *'meaning'*, and better use of the mediational teaching style. The classroom teacher thought that the improvement in mediation led to the high performance the Grade 5 learners displayed.

The next chapter will offer an interpretation of the findings of both cycles of inquiry around three main domains: first, it will deal with how the findings regarding teaching thinking skills in science to learners with special needs corroborates with data published in the literature. In particular, issues related to teaching thinking skills, their transferability to other learning areas, acquisition of science content-knowledge, the suitability of Instrumental Enrichment as a programme to consolidate basic skills will be discussed. A second discussion will look at *action research* as a way to evaluate intervention programmes and as a way for teacher-researchers to enhance their professional growth. Lastly, some implications of this study will be discussed in relation to South Africa's policy regarding teaching thinking skills in the Natural Sciences Learning Area and the Inclusion Policy regarding learners with special needs.

Chapter Five

An Interpretation of the Findings

5.1 Introduction

This chapter focuses on three main aspects, which provide greater insight into the intervention programme, particularly its effectiveness and quality.

Firstly, I discuss the findings of the research in the light of literature reviewed, linking the emerging themes with previously published knowledge. Aspects of the literature that I specifically focused on relate to science instruction, acquisition of science content knowledge, and improvement in thinking skills. Other aspects include the suitability of this programme in meeting the learners' special needs, the effectiveness of Instrumental Enrichment, and the effectiveness of mediation as a way to develop thinking skills explicitly.

Secondly, I discuss methodological aspects of the programme, particularly the appropriateness of action research as a model for evaluating programmes of this kind. Specifically, I look at the role of the teacher as a researcher, as an observer and evaluator, and action research as an approach to facilitate professional development. I will discuss the practice of teaching and collaborative aspects as they emerged from the research, and also the advantages and disadvantages in using videotaping as an observation method.

Thirdly, I will critically discuss South African curriculum policy, which integrates thinking skills and processes into the Natural Sciences Learning Area of Curriculum 2005. I will also discuss the implications of the transferability of these processes to everyday life. I then look at some issues related to the inclusive education policy and its suitability to learners with special needs.

5.2 Critical Discussion of the Two Cycles of Inquiry

The main aim of the intervention programme was to find a balanced emphasis on teaching thinking skills and processes in a context of science content knowledge to learners with special needs. By finding this balance, learners with special needs will be provided with strategies to solve problems in science and helped to become more independent learners.

The increasing interest in teaching thinking skills to learners is evidenced by the appearance of intervention programmes aimed at improving thinking skills of learners with a wide range of abilities and across different disciplines. Robinson (1987, p. 16), for example, states: 'Teaching children to become effective thinkers is increasingly recognised as an immediate goal in education.... If students are to function successfully in a highly technical society, then they must be equipped with lifelong learning and thinking skills necessary to acquire and process information in an ever-changing world' [in (Cotton 2000) p. 2].

At the same time as we are witnessing the emergence of intervention programmes aimed at teaching thinking skills, criticism of the process-led approach is also being voiced. The main criticism is that a swing towards an over-emphasis on thinking skills has taken place [(Wellington 1989) p. 18]. The process led approach is based on the assumptions that 'science for all abilities' necessitates a process-based curriculum, and that skills, particularly transferable skills, are more relevant to learners than knowledge [(Wellington 1989) p. 15]. Wellington questions the suitability of process-based education for all learners, its relevance to learners, and questions whether these processes are transferable to other learning areas. Millar questions whether processes and skills can be taught and whether they could be assessed effectively [(Millar 1989; Wellington 1989)].

I will appraise these arguments critically and try to shed more light on the issue, and also attempt to justify my choices of the design of the intervention programme. I will start by describing how the findings of my teaching programme associated with improvements in the use of thinking skills and processes, acquisition of knowledge and transfer of thinking skills to other learning areas reflect what is described in the literature.

5.2.1 Acquiring Thinking Skills and Processes

Science education as a course of study traditionally prepared learners for higher education, and as a consequence was relevant or suitable only to learners with high or average abilities. Placing an emphasis on thinking skills and processes, it is claimed, allows more learners to benefit from science instruction [(Jenkins 1989) p. 42]. Wellington claims that 'the belief that the processes of science are in some way simpler and more accessible to pupils of lower ability is based on a mistaken conception that scientific observation, classification and so on are independent of theory' [(Wellington 1989) p. 9]. McPeck similarly argues that thinking is always thinking about something and that thinking skills cannot be taught in isolation, but rather that they are context-dependent [(McPeck 1990) p. 19]. Millar (1989) goes even further, arguing that when teachers claim they teach classification or observation, they actually mean that they teach scientific observation or scientific classification, since the basic skills are skills we use from very early ages [(Millar 1989) p. 53-54].

My first claim is that by placing an emphasis on basic thinking skills and processes and establishing learners' mastery of them, we provide more learners with the opportunity to move from basic levels of understanding to higher levels of application of the skills, in science for instance. Bell (2002) refers to this when he notes 'that helping children become proficient in the different elements of each of the process skills is an important step towards improving their access to science and their self confidence' [(Bell 2002) p. 160].

There is no doubt that scientific processes and skills depend on science theory, but the ability to master them depends strongly on becoming proficient in the basic skills first. Basic skills such as classification, comparing, observation and so on, do not necessarily depend on specific theory. In fact, some of them are known to be manifested by learners from an early age, like being able to compare two pieces of chocolate and choose the bigger piece, or classifying basic pictures according to their function, shape, etc. [(Millar 1989) p. 53, (Hoffman and Feuerstein 1988b) p. 3]. Nevertheless, the use of these skills, especially at higher levels, is not always fully developed, although they might be necessary for scholastic tasks. For example, being able to systematically compare objects on the basis of specific criteria, or effectively classifying depends on the ability to recognise the features of the objects, recognise similarities and differences, group the objectives according to the similarities between their features, and excluding objects according to differences between them. The need to make these steps explicit is important so as to help learners with special needs become proficient in them [(Bell 2002) p. 160].

I will use two examples to demonstrate the importance of teaching the principles of thinking skills explicitly. When introduced to the principles of comparing, the Grade 5 learners struggled to compare objects at the required level by either over-generalising or under-generalising. Many of the learners were using a common part of the whole when comparing objects or characteristics that were too broad. For example, when comparing two pictures of *'people'*, many learners wrote that both have, for example, a *'heart'* or *'mouth'*, or, on the other hand, both are *'made out of matter'*. When comparing pictures of an orange and an apple, some of the learners wrote that the fruits differ in the stem and the leaf, which the orange had and the apple not. After I mediated the aspect of over-generalising or under-generalising, by specifically demonstrating the principles and bridging it to other examples, most learners provided more appropriate answers and some were able to verbalise them as well (as I described in detail in Chapter 4). This may show improvement in one aspect of comparing, that is, that over-generalising or under-generalising should and can be avoided, as displayed by the Grade 5 learners.

A different example of improvement was the ability to compare two quite different animals like a *fish* and a *bird* or to ''fix'' a wrong comparison such as: 'a bird has wings' and 'a fish has gills', according to the functions of organs. At the beginning none of the learners were able to solve this specific problem. I mediated the principles to the learners by using a different, simplified example. As a result, all of the learners applied the principles successfully to similar problems (as described in the section on findings in Chapter 4).

The important point here is that, although the skill of comparison is a basic skill already applied during early childhood, not all aspects of comparison are necessarily fully developed at that stage, nor are the learners fully aware of what systematic comparison entails. (Interestingly, for the majority of the learners the ''wrong'' comparison of the *fish's gills* and the *bird's wings* appeared to be correct, and also for some of the adults I spoke to informally, explaining the topic of the research that I conducted). What I show is that mediation of principles, identification of specific errors, sources of mistakes and misunderstanding of concepts can increase awareness of these aspects and help the learners to apply them better. First, learners learn to apply the thinking skill or process at the basic level of simple, sometimes content-free tasks, and later to tasks of the particular subject matter. The Grade 6 learners showed an improved application of the thinking skills and processes learned, in terms of their ability to apply the thinking skills and processes to different tasks, and in terms of how many of the learners applied the principles correctly by the end of the intervention programme.

Another concrete example relates to the ability of the Grade 6 learners to classify. They classified circles (big and small, black and white) according to their shape and size successfully. All seemed to solve this problem adequately. However, when asked to classify various shapes (triangles, circles and squares) according to both their size and shape, which is a similar application of the skill to a more complex task, none of the learners applied it correctly. Only after a second discussion in which the principles of linear diagram were mediated, and learners were told that classification must first be done according to one criterion (for example, size), and only then according to the other (shape), the learners applied it successfully.

Again, the point I want to make is that by identifying a specific difficulty in the use of the linear diagram, and explicitly addressing it, I was providing the learners with an opportunity to become aware of specific principles, which the learners almost immediately applied in the science context.

So, if the basic skills and processes are not fully developed, although they can be manifested partially by the learners, we cannot and should not expect learners to manifest adequate use of them when solving tasks at higher levels, such as in the context of learning science. In both cases I described above, displaying difficulties in solving classification or comparison tasks in science subject matter would reflect a lack of specific basic processes and skills, rather than a lack of subject matter content knowledge or understanding of concepts. Providing the learner with the means to use a skill properly might be the basis for enabling him/her to use such a skill effectively in the context of the particular subject matters.

In other words, we can make science instruction more accessible to learners with wide ranges of abilities by opening the doors to basic understanding by first providing opportunities to master basic skills which are prior knowledge to science thinking skills and processes (without contradicting Wellington's claim for science thinking skills and processes to be theory based).

In the findings section I showed an increase in the adequate use of thinking skills, manifested by learners being more precise and choosing more relevant answers, by an increase in creativity, fluency and originality; and by the personal improvement of specific learners and more learners using thinking skills and processes throughout the term.

More particularly, the Grade 5 learners showed an adequate use of the thinking skills they learned; for example, they used the six-step approach to plan novel tasks, including planning a scientific investigation. The learners defined the goal and gathered information related to it, and identified a possible frame of rules, which might guide their work, and worked according to it. They were generating strategies (sometimes more than one) to solve their problem(s), and found ways to check if their strategy had worked. The learners could apply the 'six-step approach' to planning successfully to tasks administered to them in the context of science learning and, according to the classroom teacher, to tasks of other learning areas based on the principles they had learned in the science lesson.

The Grade 5 learners demonstrated an ability to use the linear diagram, which was introduced to them for the first time, when classifying different things into groups in basic tasks and in a science learning context. In addition, they used it in other learning areas (phonics and mathematics) and were able to apply the principles as mediated to them. Given the fact that the Grade 5 learners were younger, and had less science knowledge and strategies to solve problems, than the Grade 6 learners, they coped more than adequately with the science content knowledge and skills – so much so that the classroom teacher considered the second cycle to be more successful. These findings suggest that the approach to teaching thinking skills and processes explicitly and bridging them to science learning area enabled the learners to cope well and that it is therefore suitable for learners with special needs. In terms of the learning outcomes specified for the learners' level, the Grade 5 learners demonstrated that they could plan investigations effectively and conduct experiments to some degree. They classified effectively and recalled information meaningfully when required and could apply this in solving problems which had not been taught explicitly. The abilities demonstrated by the learners are all reflected in the learning outcomes specified in the RNCS (2002) for the intermediate level (Grades 4-6) [(Department of Education 2002), p. 30].

The Grade 6 learners had a better starting level on all the thinking skills I chose to teach and manifested a mastery of the skills and processes to a greater extent than the Grade 5 learners. They picked up the principles faster and applied them more accurately, demonstrating an adequate ability to use them. They showed an increased use of vocabulary related to the different skills, communicating precisely what guided their work and how they arrived at a specific conclusion. Increasingly, learners applied the principles to novel tasks as the term proceeded and it seemed that learners were developing self-awareness of their own thinking. The Grade 6 learners also showed an increase in creativity, specifically in fluency and originality. When hypothesising, they were critical about the strategies and ideas they offered and could explain their choices, realising that these ideas could be wrong and that they needed to be proven first. The Grade 6 learners manifested most of what is expected at the end of the intermediate phase, namely, planning, conducting and evaluation of scientific investigations, collecting data and communicating them efficiently (as required by (Department of Education 2002), p. 29-30). Moreover, they recalled meaningful information and applied it correctly on novel tasks. The learners compared, classified, hypothesised, inferred and controlled variables in an efficient way, as I described in the findings section in Chapter 4. All of these processes and skills are in line with what is specified in the RNCS [(Department of Education 2002), p. 13-14], as expected at the end of the intermediate phase (Grade 6). What may be suggested is that this approach could facilitate learners' abilities to develop the thinking skills and processes reflected in the critical and learning outcomes defined in the RNCS (2002).

I have described an increased use in thinking skills and processes in the finding section (Chapter 4), as I perceived it as a teacher and observer. Though it is a subjective interpretation, I have used specific criteria to assess the learners' performance, for example, the ability of learners to apply the principles of the skills to novel tasks, generating new ideas and strategies, adequate use of vocabulary and understanding of science content knowledge. When claiming to teach something, whether content knowledge or thinking skills and processes, one must be able to assess the improvement in performance. Assessing skills and processes is always difficult and a measure of subjectivity might always be involved, even if assessment criteria or performance indicators are provided. Millar criticises the ability to assess learners' performance in tasks which involve processes by saying that this will imply knowing what is an easy 'observing' or easy 'hypothesising' task, and what is a 'harder' or 'more advanced' task. Put differently, what is 'elementary' classification as opposed to 'advanced' classification and so on. [(Millar 1989) p. 57]. If we look at Feuerstein's IE Instruments, there are some good examples of different complexity levels of skills such as comparing, classifying, following instructions, etc. Generally the differences between complexity levels are manifested by the level of abstract content used in the exercise, number of objects to be classified or compared, etc. The point I want to make is that the ability to apply the principles of a specific skill to content that differs in complexity can serve as a way to gradually learn to use the skill better. This in turn can also serve as a way to assess the ability to use the thinking skills or processes. When I refer to 'an increased ability to use the thinking skills' as manifested by the learners, I mean that the learners were able to apply the principles of the skill to novel tasks in science or other learning areas. I will demonstrate this using a few examples from both the Grade 5 and 6 programmes.

In both cycles the learners had to apply the principles of skills to new content, or content which they had learnt beforehand. For example, they applied the principles of the Venn diagram by comparing liquids, specific creatures from the Odyssey programme, animal's characteristics, the MTN Centre's rocket and a rocket we made in the classroom, and so on. Similarly, they classified animals, means of transportation, water in different states of matter, etc. using the linear diagram. They had to apply different skills and processes to science content knowledge but also to everyday problems.

In order to assess the learners' performance, I used tasks that were similar to the tasks in the teaching phase. Assessment of skills and processes is often criticised for ‘‘teaching to the test’’, because the novel tasks are too similar to the ones used in the teaching phase

[(Bransford *et al.* 1986) p. 69]. On the other hand, sometimes there is no direct link between the test questions and the tasks in the teaching phase. If that is the case it may be complicated to demonstrate a better use of thinking skills and processes [(Bransford *et al.* 1986) p. 69]. Even if the type of tasks I used would be considered as ''teaching to the test'' (which I personally do not think is the case), the learners in both cycles used the principles of many skills and processes more than adequately in the tasks presented to them. I regard the learners' performance in these tasks as demonstrating an increased ability to use these skills effectively. If we were to make reference to the RNCS (2002) assessment standards, this would be considered as a demonstration of learning outcomes 1 and 2 mainly (Carry out Scientific Investigation and Constructing Science Knowledge). These achievements may suggest a better use of skills and processes manifested by the learners, as well as their understanding of scientific concepts. The quizzes and worksheets support this notion, as does the classroom teacher.

In summarising these achievements, it is evident from the data that the learners made adequate use of the thinking skills and processes in the learning of science and in some content-free tasks. Nevertheless, I do not claim that I taught the thinking skills and processes from scratch, but rather made some aspects of these skills more explicit to the learners, helping them to become aware of certain principles and providing the learners with opportunities to practise them. As mentioned before, I mediated situations so that the learners could apply and gain mastery in the use of various thinking skills and processes, as well as providing opportunities to question, make mistakes and discuss these principles. Moreover, learners were provided with opportunities to successfully apply them to novel, similar and different kinds of tasks.

Evidence of improvement in the use of thinking skills and processes is corroborated in the findings of many studies in the literature. Zohar, Weinberger and Tamir report improvement in use of critical thinking skills if compared to initial level of use, and when compared with proper controls [(Zohar *et al.* 1994)]. Similar studies produced similar results [(Moll and Allen 1982; Shaw 1983; Shayer and Adey 1992a; Shayer and Adey 1992b; Statkiewicz and Allen 1983; Warsham and Austin 1983).

Lazarowitz and Huppert have shown that a combination of thinking process with the inquiry method is both possible and effective. They report that learners exhibited more

Fluency (as many ideas as possible), Flexibility (different types of ideas) and more original ideas, when compared with control groups [(Lazarowitz and Huppert 1980) p. 228]. The learners of both cycles, but in particular the Grade 6 learners, showed an increase in creativity, manifested by an increase in originality and increase in Flexibility as the intervention programme proceeded, which corresponds with findings of the study of Lazarowitz and Huppert.

All of these studies showed an improvement in applying thinking skills and processes based on the infusion approach, where the skills are integrated into the regular science curriculum. My findings suggest an improvement in applying thinking skills and processes after explicit teaching of the principles of skills and processes to context-free tasks, and later bridging them into science contexts.

There is no doubt that scientists (and others) develop a mastery in being able to observe, classify, compare, etc. Practising the use of skills and processes is essential, and it is evident that the use of thinking skills and processes can improve and bring proficiency at a later stage. According to Feuerstein, unless practised intentionally, these skills and processes would develop slowly, not necessarily completely, or might not develop at all [(Fisher 1990) p. 131]. Millar (1989) claims that the thinking skills and processes are not particularly related to science but 'are simply convenient labels for general approaches which we all use all the time in making sense of the world' [(Millar 1989) p. 51]. He also claims that 'scientific enquiry cannot be portrayed as rule following but involves the ***exercise*** of skill: in deciding what to observe, in selecting which observation to pay attention to, in interpreting and drawing inference, in drawing conclusions from experimental data, even in replicating experiments' [(Millar 1989) p. 51]. These points provide the basis for my next argument. The question that requires answering is: to what extent can we teach thinking skills and processes in a specific context or in general? Whether they can transfer to other learning areas or not, or whether we can assess them does not negate emphasising the explicit teaching of thinking skills and processes. Since they are *the* general approaches we use all the time, making an effort (explicit or implicit for that matter) to gain mastery of them is worthwhile anyway.

5.2.2 Content

When referring to thinking abilities, questions regarding content knowledge must be considered, because we are required to adapt to and evolve in an ever-changing world. Almost by definition, understanding how the world functions and operates demands knowledge as well as skills. In other words, to be able to predict certain phenomena, to be able to infer, hypothesise, plan, etc., one must know the discipline's rules, principles and theories that guide them, which involves content knowledge. Here I would like to clarify that, although I integrated processes and skills, based on the strong belief of their importance, I did not neglect to teach science content knowledge, which enabled the learners to use the skills in an appropriate context. For example, I wanted the learners to be able to *classify* (which is one of the skills I chose for both the learners in Grades 5 and 6) based on the specific scientific *theory* (which served as the content knowledge) like feeding habits or phases of matter. Wellington claims that science thinking skills and processes are based on scientific theory, which is essential for proper application of the skills and processes in this field [(Wellington 1989) p. 9]. By teaching the skills and processes in the scientific context, I basically followed – and thus acknowledged the force of – his argument.

The content I chose and used in this study over the two cycles of inquiry was based on the syllabus for the different grades, as recommended in the science textbook for Grades 5 and 6. In the first cycle of inquiry I looked at the content of the book and integrated thinking skills that I thought would easily fit the content of the syllabus. The list of thinking skills and processes I ended up teaching combined some of the thinking skills and processes offered in the syllabus from the textbook, and some of my own ideas of science thinking skills. However, in the second cycle of inquiry I started with a specific list of skills I intended to teach, because they were the most important thinking skills and processes suitable for this age and fitted the time frame I had planned. I chose the content from the textbook and its syllabus in such a way, that it would fit as a vehicle to teach the skills I decided upon.

Being accustomed to teach according to a content-based curriculum, the almost instinctive approach I used in the first cycle of inquiry was to look at the content first and embed thinking skills into it. However, in the second cycle I started designing the programme by deciding which of the thinking skills and processes I am going to mediate and then I looked at what syllabus content knowledge would fit as a vehicle to do so. I regard the difference in the designing phase between the cycles as a mind shift from a content-based mindset to a process-based mindset. Both cycles provided a programme that placed an emphasis on thinking skills and processes in a scientific context; however, the second cycle was more structured in terms of consolidating the thinking skills that were taught. This might be one possible explanation for the success the Grade 5 learners showed in applying thinking skills so accurately, in spite of the fact that they were younger and less experienced than the Grade 6 learners.

In both cycles acquisition of knowledge by the learners occurred to a greater extent than predicted by the classroom teacher. This indicates that placing the emphasis on thinking skills does not necessarily mean that less content would be taught (as was the case with the Grade 6 intervention programme) or that learners will not demonstrate an understanding of the science concepts, as was the case in both cycles. With the Grade 5 learners I planned to teach less content knowledge, bearing in mind that this balance between content and skills can be optimised within a longer time frame. I taught only a bit more than half of what is recommended for a normal term in mainstream schools for Grade 5 learners. Nevertheless, the classroom teacher regarded this amount of content knowledge as more than adequate for these learners. The important thing is that the learners, although displaying short memory spans (problems of recall and focus), showed a good understanding of science concepts and content knowledge. The learners in both Grade 5 and 6 could recall meaningful information and apply it to novel tasks, which (as I mentioned) reflects some of the learning outcomes expected of this age level (RNCS, 2002, p. 29-30).

Studies report that, even if the content knowledge plays a secondary role in the intervention programme, acquisition of content knowledge and manifestation of an understanding of complex concepts occur in addition to an increase in the use of thinking skills and processes [for example, (Zohar *et al.* 1994), (Adams 1993), (Novak and Dettloff 1989), (Moll and Allen 1982), and others]. My findings corroborate the findings of these studies.

Content knowledge was claimed to be less relevant than skills and processes for average and below-average learners, and Wellington raises a general argument that whether content knowledge or skills and processes are relevant to learners depends strongly on learners' age, moral, social and intellectual development, point in time, social demands, etc. [(Wellington 1989) p. 13]. The question of relevance must be addressed by curriculum developers, educators and teachers through choosing relevant content knowledge or relevant skills and processes based on all or some of the parameters mentioned above. As Kirkham stresses: '…they (the topics and experience) should appear relevant to them (the learners), should deal with the science, and its applications, of themselves and their world…. If we cannot relate the topics directly to our pupils, there is little justification for retaining them' [(Kirkham 1989) p. 140].

Certainly, there is no reason to think that processes and skills are more relevant than content knowledge. The science curriculum should aim to be relevant to as many learners as possible, addressing issues in interesting and engaging ways and being suitable for all learners. The same principle should guide the choice of skills and processes, which can also be found to be not relevant and can be forgotten unless used frequently. The point I want to make is that thinking skills and processes should be taught in addition to science content knowledge and not instead of it, and both of the discipline's domains should be chosen on the basis of being relevant to as many learners as possible. As a general concept, this guided my choice to teaching thinking skills and processes as well as content knowledge.

The content I chose for both cycles of inquiry was adapted from a few science textbooks [(Cadle *et al.* 1995a; Cadle *et al.* 1995b; Clacherty *et al.* 1998)] and a few encyclopaedias. However, in most cases I did not use the material as is, but adapted it to my needs in the sense that it served as a vehicle to teach thinking skills and processes. What guided my choices of content was how exciting, familiar and interesting the material might be for learners. I demonstrated colourful and exciting experiments, chose familiar situations which the learners could refer and relate to, or touched on issues that concern them in particular, such as animals and habitats, phases of matter, medical issues, agriculture, transportation, laboratory work, etc., which was only some of the contents I used. By drawing on many and diverse issues, I was hoping to provide topics which would be relevant to as many learners as possible. Diversity of topics naturally increases the possibility to meet at least some of each of the learners' interests [(Bancroft 2002) p. 169].

Another important point I want to emphasis here is that I did not intend to create a new syllabus, but rather I used the content as recommended by the textbook. The only difference I introduced was an adapted version of the material that included the recommended content as a vehicle to learn and practise specific skills and processes. Any textbook and any syllabus can be used to combine content knowledge and thinking skills and processes, as I have demonstrated with the Grade 5 and 6 syllabuses. The special thing about my programme is the infusion of both domains to meet a combined emphasis on skills as well as content knowledge.

The second criticism raised against the process-led approach has to do with the transferability of thinking skills and processes to other learning areas and situations, which some have argued is highly questionable. Many authors doubt the issue of transferability and try to determine when and how it can actually occur. First, how does it occur in terms of the conditions that allow transfer of thinking skills and processes to happen and, second, when transfer does occur, how useful and applicable are the thinking skills and processes. I draw on some of the general arguments which influenced this study and which helped me to shape it in the way I did. I will discuss first the process of *Bridging* as a vital step for *Transfer* to happen within a specific learning area and possibly to other learning areas. Then I will discuss the transferability of thinking skills and processes to other learning contexts. Bridging and transfer are mutually inclusive; however, to simplify the discussion I attend to them one by one.

5.2.3 Bridging

Bridging or 'transcendence' as Feuerstein refers to it is 'the orientation of the mediator to widen the interaction beyond the immediate and elementary goal, and creates in the mediatee a propensity to enlarge his [*sic*] cognitive and effective repertoire of functioning constantly' [(Feuerstein and Feuerstein 1991) p. 21-22]. This is achieved by explicit teaching of the basic skills and then linking/bridging/associating them to different situations where the skills can be applied, and also to encourage the learners to generate similar occasions/situations where they can use them [(Haywood 1993) p. 35]. (Since Feuerstein's intervention programme is intended to be taught as a programme on its own (i.e. not integrated to a specific discipline), the bridging should be to events and circumstances that are familiar to the learners, should be elicited from the learners, and should be simple and straight forward [(Haywood 1993) p. 35].)

I taught specific skills and processes within a specific science context, and bridging between the skills and the tasks/situations where they can be applied was almost an immediate thing. For example, after mediating the principles of comparisons, the Grade 6 learners had to compare different things first in everyday life and then in science contexts. They compared various pictures of objects and people, stating what is common and what is different between them. Then they compared various solutions they had prepared and defined the criteria they used to compare them, such as colour, smell, taste and so on. The Grade 5 learners compared the classroom teacher and myself according to different criteria they chose to compare us, for example, marital status, height, hair colour, etc. Further, they compared particles of water in different phases and different properties of liquids. These are all examples of the bridging of thinking skills and processes to different contexts; more examples were mentioned in the findings section of different skills I taught in Chapter 4 (Grade 6 learners and Grade 5 learners). What I found in both cycles is that after I initiated bridging between the basic skill or process to scientific problems as well as other contexts, the learners manifested an ability to use and apply the skills to novel tasks. The classroom teacher confirmed that they had internalised the skills or approaches, and applied them in a scientific context and to some extent also in other learning areas. The ability to use basic skills and processes effectively after bridging takes place is confirmed by Freseman's (1990) results. He concluded his study by stating that '...thinking skills need to be taught directly before they are applied to the content areas.... [I] considered the concept of teaching thinking skills directly to be of value especially when there followed immediate application to the content area...'[p. 48, in (Cotton 2000) p. 8].

Bridging is a necessary process, which takes the learners beyond the level of the basic skill or approach, to a higher level of where the skill can be applied, and by so doing creates a nexus between the two. With the Grade 6 learners I bridged the skills and processes mainly in a science context and to other contexts to a certain extent. The classroom teacher confirmed it by saying:

> So what the goal was for that day, I would say we achieved the goal of observing very well, but there was a transference or bridging to other things. I was almost sure that they immediately internalised the act of observing...' (Appendix F: Interview script, 2002, p. 1)
>
> '...It came to them like THIS. They could immediately apply the knowledge gained through bridging to the science lessons that followed and followed the classification...' (Appendix F: Interview Script, 2002, p. 6)
>
> *How was the bridging from the instruments themselves towards science topics?*
>
> I thought very good, excellent. (Appendix F: Interview Script, 2002, p. 6).

Nevertheless, in terms of transfer of the thinking skills to other learning areas in the first cycle of inquiry, transfer appeared to be a bit limited. At the end of the first cycle I was quite disappointed with the evidence of transfer generated from the data. I made a specific note to myself that it might have to do with the ability to bridge and the frequency of bridging the skills to other learning areas. Kozulin (1993) claims that the presence of special bridging exercises to content areas of the curriculum constitute the decisive factors of success in IE implementation [in (Kozulin and Presseisen 1995) p. 73]. For example, Blagg (1991) implemented IE in England and found 'difficulties tracing the ability of IE instruction to increase the likelihood of transfer to other areas of the curriculum'. Blagg's work was criticised by Haywood (1992) who argued that his implementation had some serious flaws in areas of teacher training, supervision and the amount of IE the student received. [Both Blagg (1991) and Haywood (1992) cited in (Kozulin and Presseisen 1995) p. 73]. Sternberg and Bhana evaluated Instrumental Enrichment, among other intervention programmes, and confirmed this notion. They comment that 'there appears to be transfer to school work in some cases, although we are less confident of the generality of transfer, in part because the extent of transfer attained will be so much a function of how well teachers are able to conduct the required *bridging*' [(Sternberg and Bhana 1986) p. 63].

5.2.4 Transfer

The bridging process is crucial for transfer to happen, since without the bridging process the basic skill or approach is isolated from any applicable context. However, this is not to suggest that whenever a skill or a process is bridged that transfer will always occur. I find that the bridging process can raise the likelihood that transfer could happen, but there is no guarantee that it will.

During analysis of the first cycle findings with regard to transfer, I became even more aware of how important the bridging process is if transfer of skills and processes to other learning areas is to happen. Bridging was more abundant with the Grade 5 learners. The classroom teacher and the video material confirmed the progress of my bridging ability, specifically saying:

> In the beginning we spoke about it (bridging) as a goal you set after some feedback from my side [referring to the interview of the previous cycle]. I think there was improvement, it was definitely much better than last year. You were constantly aware of the bridging. (Appendix F: Interview script, 2003, p. 6)

From my own experience, evidence for bridging was manifested in both cycles of inquiry around various skills and process to different contexts. In spite of this, and as the data from the second cycle accumulated, I realised that when the learners were reminded of a specific skill, they applied it adequately. However, the evidence for spontaneous transfer was a bit limited and less frequent than what I had expected.

Without suggesting that my bridging abilities were fully developed, since my experience as a mediator was relatively limited, tying the ability to bridge and the transferability of the skills to other learning areas is problematic, in the sense that bridging does not necessarily indicate that transfer of the skills to other learning areas will occur. The claim that these two aspects, namely bridging and transferability, are strongly linked removes the ability to check objectively the transferability of thinking skills to other learning areas, because the ability to bridge is subjective and not necessarily quantifiable. It may be difficult or even impossible to deduce from a situation in which transfer did not occur or was manifested only to a certain extent in other learning areas, which conditions interfered, since this lack of transfer could be due to various reasons. Indeed, in some cases as reported, transferability occurred to some extent and on some other occasions it did not, and it is difficult to say which factors are responsible for making transfer possible, including bridging.

Wellington (1989) claims that transfer depends strongly on two conditions: that the domains in which skills are acquired are closely related and that transfer is explicitly taught [(Wellington 1989) p. 15]. Bransford, Burns, Delclos and Vye (1986) also claim that transferability should be taught explicitly [(Bransford *et al.* 1986) p. 69-70]. I applied these principles by suggesting similarities between the principles of the skill and the tasks, and suggested explicitly that the skill or the process can be applied in other contexts by giving a few examples and eliciting examples from the learners. I found that in science contexts this worked very well and learners manifested the ability to apply the principles of the skills and processes to novel or different content. I described a few instances in Chapter 4, where I believe transfer to other learning areas had occurred – for example, when the Grade 5 learners recognised the linear diagram in the mathematics lesson, or when the Grade 6 learners noted that the classroom teacher did not 'define the goal' and so on.

I also found that when the classroom teacher reminded the Grade 5 learners of the six-step approach to planning, which they had learnt in a science lesson, the learners could use the approach effectively in the other contexts (like in the social skills class or when designing a Japanese hall for international day). What the classroom teacher was doing is parallel to bridging of the specific approach taught (by me to the learners in the science class) to other situations where it might be applied. In the second interview the classroom teacher described what he was doing in the social science class:

> I asked her [the social science teacher] permission to just add one thing and that was: we stopped the two groups and we said to them: remember what you have learnt with Nilly. Now define your goal: what does group No. 1 have to do and what does group No. 2 have to do. Now, look at the information you've got and decide on what still you need and on what strategy you are going to follow. And work out the rules. And we backed off. (Interview script, 2003, p. 2)

The learners, as he reported, knew ''exactly'' what to do. He was creating the link by associating one technique with a different problem in different contexts. This example demonstrates that bridging to other situations and different learning areas helps to increase the association between the skill or process and various possible applications, which might eventually lead to voluntary and spontaneous application by the learners at a later stage.

However, McPeck questions the worth of such a transfer, claiming that the more general the principle, the less it is going to be useful and applicable to solve particular problems, and the more specific the principle or approach is, the more transferable it is to other similar situations. In other words, McPeck claims that general approaches are functionally meaningless, whereas a specific approach to a particular problem is very useful but limited to specific, similar types of problems [(McPeck 1990) p.14].

Since I taught only the science lessons, I could see transfer of skills occur mainly within science subject matter. My evidence of transfer of specific skills within the same subject matter but to novel tasks on various occasions is in line with McPeck's claim of transferability of particular approaches to particular situations, such as when using the principles of classification for novel content. In addition to that, the Grade 6 learners reported in a few (3) questionnaires that their confidence in using the skills in other learning areas increased. The classroom teacher reported in both interviews that he feels there were 2-3 occasions in each cycle of inquiry where he recognised transfer of the skills to other learning areas. I was not present in those specific situations where the learners and the classroom teacher reported transfer of skills, and I must therefore rely on their testimonies. It is known that occasionally interviewees who answer questionnaires try and deliver the type of answers they believe is the ''right'' or ''preferred'' answer that the interviewer requires [(Hitchcock and Hughes 1995) p. 158, 168]. If this is the case, then my findings support McPeck's opinion only to the extent that particular approaches do transfer to other specific similar situations. However, if their reports of transferability of thinking skills and processes to other learning areas represent reality to some extent, then they should be taken into consideration. The classroom teacher's and the learners' reports might indicate that there is some transferability of thinking skills and processes to other learning areas. Some examples were manifested in the phonics and mathematics lessons in which they recognised the skills and used them efficiently (see Appendix J). Other examples were related to the application of the skills and processes in the social science lesson or in the preparations for international day. Although I cannot provide solid evidence of transferability, there appears to be some basis to believe that transfer can occur as a result of this type of teaching.

This is in line with what Bransford *et al.* claim, namely that 'blind' instruction, in which the teaching of thinking skills and processes, or their transferability are implicit, usually does not lead to transfer of thinking skills to new tasks. However, when the instruction focuses on helping learners become problem solvers who learn to recognise and monitor their approaches to particular tasks, transfer is more likely to happen [(Bransford *et al.* 1986) p. 69-70]. This also suggests that the explicit teaching of thinking skills and processes might be more potent in terms of transfer of these to other learning areas.

I was trying to create the circumstances by which, according to Kirkham (1989), transfer can occur. He points out that learners can practise and become successful in applying knowledge and skills developed in one part of the curriculum when working in another, but for that 'we must teach in a cross-curricular manner' [(Kirkham 1989) p. 140-142].

Ultimately, from a holistic point of view, if skills and processes ought to be used by learners, we must marry them to as many situations in as many different contexts as possible, as was the case in my science bridging and the classroom teachers' intervention. This in turn may eventually allow learners to apply the skills or processes spontaneously to novel tasks and would be considered as proper transfer.

In summary, according to my experience in two cycles of inquiry, and along with what seemed to transpire from the literature, for transfer to occur, one needs to mediate the principles of various thinking skills and processes explicitly, and bridge them to a wider science context and to some extent also to other areas of the curriculum. Under these conditions, it appears that transfer of thinking skills and processes occurs within the subject matter and may occur to some extent also to other learning areas.

Regardless of the extent to which transfer did occur in my study, I would like to use McPeck (1981) words to describe my own feelings about transferability of thinking skills and processes:

> While conscientious teachers hope that their results will transfer to other areas, they should be content with success in their own area, since there is little reason to believe that the required skills in other areas will be exactly the same.'

[(McPeck 1981) p. 17]

I am very satisfied with the results that indicate a better use of thinking skills in a science context and even a bit beyond it. If more and more evidence for adequate use of the thinking skills is produced in the course of time, it will be of additional value.

I shall now describe the findings in light of the mediational aspects as an index for teaching quality and the suitability of the programme to learners' needs.

5.2.5 Mediation

Feuerstein claims that the best way to evaluate the mediational quality of an interaction between a teacher and learners is to 'detect how different is the mediated event from the regular one, how different is the speech of the teacher when he [sic] merely transmits an instruction from when he [sic] mediates it to the students' [(Feuerstein and Feuerstein 1991) p. 18].

Being able to mediate requires a shift on the teacher's part from the traditional teaching style, with its emphasis on the transmission of knowledge and its recall, to a mediational teaching style, which is quite different in many respects. Successful mediation requires the mediator to ensure that the learner is aware of and understands what s/he is going to do, why s/he is doing it, and that the act has a value beyond the here and now [Burden and Florek, 1989 in (Head and O'neill 1999)]. In other words, teacher-mediators help the learners become metacognitively aware of the *meaning* behind specific learning material, why it is important and how to go about it. Teachers who practise what is known to be representative of good mediation, according to Haywood (1993), 'help children reduce the number and complexity of stimuli and help the learners to focus on its relevant aspects. They repeat exposure to important stimuli, perceive understanding of similarities and differences, sequential relationships, dimensionality, antecedents and consequences, …and grasping the concept of generalisability of experience to new situations' [(Haywood 1993) p. 31].

One way to familiarise oneself with aspects of mediation is through the Instrumental Enrichment course. The IE training course introduces mediation and the mediational aspects of teaching, and provides opportunities to practise mediation and get some feedback about it from the trainers. However, mediation is a skill and the teacher needs to acquire and practise it in order to become an efficient mediator.

In the first cycle of inquiry, half a year after I was trained in IE, and having familiarised myself with some of the literature about mediation, I tried to implement the principles of a *mediated* teaching style.

During both cycles of inquiry I had conversations with the IE trainer, which provided me with some support regarding specific issues in mediation. At the end of the first cycle of inquiry, the classroom teacher commented on my mediational abilities:

> You listened very carefully and as we spoke and reflected on the lessons, from lesson one onwards, initially there wasn't mediation, later the mediating came more and more and played a greater role. (Appendix F: Interview script, 2002, p. 8)
>
> The mediating aspect, Dr. Worral would tell you that you are a good mediator after 2 years of practice. You've been here exactly 3 months and we saw with the after-lesson discussions that we had, that it did come in and that's the only other thing I could think of. It's not something that comes naturally. (Appendix F: Interview script, 2002, p. 9)

The video material confirmed an increase in mediating incidents and increased use of opportunities to mediate during the lesson. My mediational teaching style had started to take shape and was evident in dialogues in which learners could express the ways in which they thought, challenging right as well as wrong answers, requesting justifications for both, placing an emphasis on meaning, principles and rules, and of course the use of bridging.

I was following the mediational teaching approach during both cycles. I was trying to provide the meaning behind a skill or a process I chose to teach (i.e. by explaining the importance of the skill or process, how and where it can serve as a useful tool and so on). Also, I was mediating why we learn specific content, in what ways it affects our life, etc., all of which is part of mediating the meaning behind the content. I was enthusiastic about teaching and inspired enthusiasm in the learners to learn, as was reported by the classroom teacher in both interviews and in the learners' questionnaires, and was also confirmed by the video material. According to Feuerstein [(Feuerstein and Feuerstein 1991) p. 17], these are important in terms of Reciprocity and Intentionality. The evidence for better mediation started to accumulate and at the end of the second cycle of inquiry the classroom teacher suggested that it was the mediational aspects that made the second cycle of inquiry so successful. In his words:

> [B]ut an overall general feeling about the way you went about it this year compared to last year, is to say that [pause]… Somehow I get the feeling and maybe your results will show that we were more successful with this group, despite them being younger. What comes into mind straight away is the mediating aspect from your teaching side of things. (Appendix F: Interview Script 2003, p. 1)
>
> Compare it to last year, there is a significant difference in my opinion. I have no doubts in my mind that the mediation in general and across the 16-17 lessons done was a great improvement on the last year. And that when we had our feedback sessions after the lessons - the few little improvements that we wanted to make would be carried forward into the following lessons. (Appendix F: Interview Script 2003, p. 8)

Another manifestation of successful mediation is an increase in the frequency and quality of the critical dialogues held in the classroom, mainly evident with the Grade 5 learners in the second cycle of inquiry. In the first cycle of inquiry the Grade 6 learners manifested specific levels of understanding of the basic skills I chose to emphasise. However, when they were struggling, as they did with the principles of comparing or classification, my abilities as a mediator to address their problems were limited in the sense that it was difficult for me to put a finger on and identify the source of the problem they were facing. With the Grade 5 learners, on the other hand, the mediation was more structured, starting from the skills and bridging to some examples. When the Grade 5 learners struggled, I addressed this with more mediation and as we continued more learners could effectively compare or classify, as well as explain why one answer was better than another one. This critical dialogue, which was guided by intentional questions, is a manifestation of mediation. As appears from the video material and from the classroom teacher's interview, there were more occasions where this type of mediation happened.

It is complex to evaluate mediating abilities as such. Obviously it depends strongly on the person who mediates and depends also on the task at hand. Haywood claims that 'there are as many specific ways to mediate cognitive functions to children, as there are good mediators. Good mediators use their own personalities and the feedback they get from the children to regulate their behaviour and to select mediational strategies'

[(Haywood 1993) p. 36]. I was combining my ability to teach science in a teaching style I had as a teacher from previous experience, my personality and a rather new mediational teaching approach that I adopted for teaching thinking skills and processes. These shaped my abilities to mediate and influenced the teacher-mediator I evolved to be.

The improvement in mediation was quite efficient and there are a few possible reasons for this. It may be partly because of the privilege I had of receiving feedback regarding many aspects of the learning-teaching situation, including the mediational aspects from a colleague/peer after each of the lessons. The classroom teacher helped me to become aware of the opportunities I recognised for using mediation, and pointed out opportunities I had missed. The reflective process of engagement I had with the classroom teacher enhanced my abilities to mediate, as well as many other aspects related to the learning-teaching situation I documented.

A second reason for effective improvement in mediation might be that I was able to track the learning situations and opportunities for mediation, which the classroom teacher mentioned in our reflections on the lessons via the video material. I had the time and means to think about how to address similar situations in light of the feedback he gave me. This, in turn, was followed by an awareness of the mediational aspects of my teaching.

The last important contribution to my improvement in mediating was the support and guidance I received from the IE trainer throughout both cycles of inquiry. She is a professional IE trainer as well as an experienced language teacher and had practised mediational teaching for many years. I used to raise issues regarding mediation and specific problems I was facing in IE or with bridging, and we used to think together of possible solutions/ideas to overcome these problems. Her input was highly important in my growth as a teacher and as a mediator, and was a source of inspiration for my study and my teaching.

Having grasped the principles of mediation as well as the theory behind it, my abilities to mediate improved during the intervention programme as it proceeded and so was instrumental in the learners' success. It is obvious but important to say that a mediational style of teaching can increase learners' performance, as supported in the literature [(Arbitman-Smith and Haywood 1980; Feuerstein and Feuerstein 1991; Head and O'Neill 1999; Messerer *et al.* 1984a; Narrol *et al.* 1982)].

To summarise, professional support, peer reflection through collaboration, and personal motivation to change and improve does bring about better practice with respect to the mediational aspect, which in turn can affect and enhance success in learners' acquisition of process skills and content knowledge.

5.3 Critical Discussion regarding Action Research as a Model for Programme Evaluation

Action research is one way in which teachers can be engaged in research with the purpose to improve the rationality and justice of (a) their own educational practice, (b) their understanding of these practices, and (c) the situation in which the practices are carried out [Kemmis, 1983 in (Hopkins 1993) p. 44]. I will discuss the advantages of action research as a model by which teachers can develop professionally as teachers and as researchers. The empowerment of teachers through curriculum design and implementation, and some issues related to the emancipation and liberation of learners and teachers as a result of action research methodology will be addressed as well. Furthermore, I will discuss the collaborative benefits of this type of research and elaborate on videotaping as a method of observation, assessment and reflection.

5.3.1 The Teacher as a Researcher

Action research has some additional value apart from being a method for doing research by practitioners. It can contribute to professional growth, empowerment of teachers and emancipation of learners and teachers by encouraging them to take control of their lives. I will discuss each of these aspects.

The teaching-learning situation is a very intimate interaction, which can rarely be described and accessed by outside individuals. Being able to explore this situation depends strongly on trust between the observer, the teacher and the learners. By conducting action research I became involved and motivated to examine the interaction between myself and the learners and to research the teaching-learning situation. By becoming an observer, I was able to critically examine and evaluate the interaction as a whole and aspects of my own practice and the learners' progress. In this regard Hitchcock and Hughes state that 'teachers-researchers can generate rich illuminating and important insights into the way in which we teach and learn in our society' [(Hitchcock and Hughes 1995) p. 10].

As a science teacher I was interested in developing an intervention programme to teach science thinking skills and processes. Put differently, I wanted to take action as a teacher which involved doing, intervening, by trying to change and improve science instruction in a specific way. I wanted to be able to say that what I was introducing as a new practice would have a beneficial effect on the learners, whether it has a positive influence on the teaching-learning situation, or whether I could change something that was missing in my practice beforehand. I was motivated to execute my own ideas and I was impassioned about them. However, I also wanted to remain critical about these ideas. By trying them out and to experience their effect on me and on the learners, I could reflect on and assess the programme as a whole – for instance, to be able to decide whether the programme's objectives were fulfilled, if my practice as a teacher improved, and whether I should carry on with the programme as is or introduce changes to it.

Action research was the approach that suited my study's purposes. It involved me as teacher wanting to introduce a change, or to implement an idea, in a systematic and monitored way, allowing me to evaluate the effectiveness of my action.

The nature of action research as small-scale research conducted by practitioners allows teachers to improve their practice both in terms of teaching and in terms of research [(Hitchcock and Hughes 1995; Hopkins 1993; Kincheloe 2003)]. As teachers, they have the opportunity to focus, learn and inquire about one or more aspects of their teaching or the teaching-learning situation. As researchers, they learn to assess research critically and develop the ability to reflect on aspects of the teaching-learning situation and, by so doing, develop professionally. As Hitchcock and Hughes claim, research and reflection are regarded as central ingredients in the individual professional development of teachers. The skills of either conducting research or being able to assess research evidence, and the ability to engage in a critical self-reflection, have major advantages for professional development [(Hitchcock and Hughes 1995) p. 5]. The more teachers are aware of their practice by being able to explain why they are doing something, the more they can improve it by introducing alternatives to the teaching they are used to. This involves intentional deliberative action, which is followed by assessment [(Hitchcock and Hughes 1995; Hopkins 1993; McNiff *et al.* 1996)].

Teaching requires the application of technical and professional knowledge of traditional academic subject matter, the skills and competence necessary for delivery of that knowledge, and the management of the learning environment [(Hitchcock and Hughes 1995) p. 4]. Also, teaching involves a sense of how to judge the learning-teaching situation in the light of these skills and knowledge [(Hitchcock and Hughes 1995) p. 4]. Therefore, teachers need to have some knowledge of child development and learning theories, understand the learning-teaching situation, as well as have knowledge of their subject matter. As part of preparing the programme, I became familiar with theories regarding children's cognitive development, which included the work of Piaget, Vygotsky and Feuerstein, as well as the Instrumental Enrichment course I attended, which deals specifically with learners' redevelopment of cognitive functions. I was exposed for the first time to the mediational teaching style, and had the opportunity to practise it in the course and get feedback on my abilities to mediate. As the study progressed I gained more and more content knowledge regarding three main domains: science instruction, special education and cognitive development. The knowledge gains I experienced throughout this study as a teacher were enormous.

Beyond the knowledge gain, another important gain in my understanding was that the body of knowledge did not remain intact as part of background knowledge, but rather was used in the intervention programmes I designed and implemented. Hitchcock and Hughes describe this process of the teacher-researcher as one that 'ought to have the effect not only of enhancing the teacher's professional status, but also of gathering self-knowledge and practical development in such a way that practice of teaching can be improved' [(Hitchcock and Hughes 1995) p. 7]. I implemented new ideas, influenced by the knowledge I gained, namely teaching thinking skills and processes in science to learners with special needs by using selected IE instruments, and using a mediational teaching style, as mentioned earlier. This included development of material that would suit the emphasis I placed on thinking skills by adjusting the textbook material as well as looking for other material sources which might fit my research purposes.

The need to develop my own material provided me with the competence and confidence to view books critically, analyse their content and introduce changes in order to meet the learners' needs. IE was only part of the teaching style I adopted in the intervention programmes. Parallel with IE, I used relatively short tasks, which allowed the learners to concentrate and focus on specific problems, and then move on to a different task. Since most of the learners have a short memory span, it was almost essential for me to do this. The nature of the tasks was such that they were not overwhelming in terms of the amount of knowledge and texts the tasks contained, nor in terms of the tasks' complexity. On the other hand, all the tasks demanded focus and an application of skills principles learned.

The learners could engage in pair discussions, group discussions and class discussions, which allowed many of them to express their thoughts and debate on the topics and issues raised, or solve particular problems collaboratively. They could share their ideas meaningfully in more than one type of discussion, which can increase individual involvement.

I introduced games, riddles and competitions, all of which I found was very engaging for the learners. I prepared activities and experiments that served as a 'hands-on' style of learning, which also provided the learners with opportunities to move from their sitting place around the classroom. Apparently, ADHD learners need to move their bodies and release tension from time to time, and therefore being able to move their bodies or change their seating positions is considered as a useful strategy to increase learning and reduce distraction [(Neuwirth 1994) p. 16].

I used teaching aids like the projector, posters and demonstrations, all aimed to increase learner's interest and engagement. I arranged three educational outings for the Grade 6 learners, in which they experienced 'hands-on' some of the topics we discussed in the classroom. These included characterising the feeding habits of insects, as well as collecting the insects and recording their habitats, and learning about the feeding habits of both the Atlantic and Indian oceans' organisms in the Two Oceans Aquarium. One educational outing for the Grade 5 learners exposed them to various natural phenomena in the MTN Science Centre, which I used as an opportunity to practise some of the skills and processes I taught. The learners' responses to all of these activities were very positive.

In York, UK, the Science Curriculum Centre has a Special Needs Programme that exists to develop and provide training in the use of exemplary curriculum material for learners with special needs as well as others. They specifically aim at helping teachers to become '(a) confident in their teaching of science investigations to pupils with diverse learning needs, (b) employ an improved knowledge of appropriate strategies to access their pupils to the appealing practical "Hands-on" and sensory opportunities that the subject offers, (c) ensure that the material matched to the learners' literacy and numeracy abilities, and (d) appreciate, as will their learners, the benefit of and enjoyment derived from their efforts to create relevant and fun contexts for teaching and learning' [(Bancroft 2002) p. 175]. If I regard these as criteria for adequate practice, and although it is difficult for me to assess my own teaching abilities, it can be suggested that some progress in my abilities as a science teacher to learners with special needs had occurred. I developed an ability to identify specific gaps in thinking as they became manifest in specific or general tasks, and ways to address them by specific mediation, simplification and exercises. I matched the science material to learners' needs and the classroom teacher indicated that the programme as a whole and the material and experiments I introduced were suitable for the learners' needs, and that the learners of both cycles reported that they enjoyed the science curriculum I introduced.

Combining theory with practice created a strong feeling of knowing what to do, how to do it and why. It served as the main source of professional growth I experienced as a teacher. Tanner and Tanner (1975) comment that 'If teaching is to be a profession, teachers must participate in curriculum development at the classroom, school and school system levels. Professionalism is inextricably intertwined with curriculum development' [in (Carl 1995) p. 245]. As Carl (1995) writes:

> Teacher involvement is essential, not only for the institutional and curriculum development of a school, but also for the personal professional growth and empowerment of the teacher.... The teacher will therefore also have to be an agent for change. The teacher will be required to have a broad knowledgeable and understanding of educational views; a knowledge of children, a positive teaching aptitude and educational relationships and also the knowledge and expertise in

> respect of both general curriculum studies and particular subject curriculum studies' [(Carl 1995) p. 16-17, p. 245].

In summary, gains in knowledge and improvement in teaching practice in regard to bridging, mediation, material development and emphasis on thinking skills instead of content knowledge all formed part of my professional growth as a teacher.

Exposing myself to social science research literature, and becoming familiar with the terms as well as the applications of different issues in this field, were also part of my professional development as a researcher. I now turn to describe my development as a researcher in more detail.

I evaluated the effect on my practical abilities to teach science and thinking skills, on the learners' ability to learn scientific concepts and science thinking skills, and on the teaching-learning situation as a whole. The ability to evaluate these aspects systematically involved learning and being exposed to different types of knowledge regarding myself and the learners. I became acquainted with social research paradigms underpinned by different epistemological, ontological and methodological assumptions, and identified myself in one type of research paradigm particularly, which I followed to create a coherent research design. All of the above involved additional learning phases as a social sciences researcher.

Hitchcock and Hughes claim that 'knowledge and understanding of research and critical inquiry can help teachers to assess more effectively the quality and significance of evidence and claims about teaching and learning. Teachers can develop the kinds of skills needed to engage in a small scale research into their own practice… and that is an integral aspect of professional self- and critical reflection and development' [(Hitchcock and Hughes 1995) p. 3]. Since I was carrying out research and not only performing an action, I had to learn to use methods which helped me assess the gains and disadvantages of the learning-teaching situation as I created it. I decided what methods would be appropriate to use and which of these are possible to employ. I also read the relevant literature, which allowed me to take my first steps in questionnaire design, constructing of interview schedules, etc., learning the principles and following the guidelines of using these methods.

Conducting research is a self-motivating way to acquire, apply and assess knowledge, and it is also a process that can to bring about changes in practice. As Kemmis and McTaggart (1982) write: 'Trying out ideas in practice as a means of improvement and as means of gaining knowledge' [in (McNiff *et al.* 1996) p. 9]. Carrying out the research as part of university degree studies allowed me to apply much of the knowledge gained in some of the university courses I attended as well as the IE training course I participated in. Without a direct opportunity to apply it, the knowledge would probably have remained only as background knowledge.

After implementation took place, I read relevant literature, which dealt with the analysis phase, and I adapted techniques to suit my needs. Having a background as a natural scientist, I experienced a mind shift from being positivist type of researcher using mainly quantitative methods to produce data, towards adopting a critical emancipatory paradigm, in which I employed mainly qualitative methods to produce data.

Learners' background and personal lives, the school ethos and learning environment it provides, the experience of successful learning and self-esteem all differ from learner to learner, and influence the interaction between the teacher and the learners [(Hopkins 1993) p. 39]. My abilities as a teacher, my personality, the mediational style I started to implement, my background and my experience, all shaped the teacher I was and the teacher I evolved to be. I could easily relate to Hopkins's view that 'the teacher-pupil and pupil-pupil interaction that result in effective learning are not so much the consequences of a standardised teaching method but the result of both teachers and learners engagement in a meaningful action which cannot be standardised by a control or sample' [(Hopkins 1993) p. 40]. The will to change all variables, by influencing the teaching-learning as a whole, by changing and improving my teaching abilities constantly and introducing change throughout the term, and by encouraging and helping learners to change and develop, fitted better with a critical emancipatory paradigm.

I became familiar with the theory of social sciences research, which in turn shaped my practice.

In terms of research practice I learned and tried out three main aspects which formed part of the methodology implementation, namely, learning to observe, reflect and evaluate. Indirect observation was done mainly via the video. I was concentrating on teaching and therefore my observations during the lesson were used mostly as part of the reflection, but some observation from a teacher's point of view was also used; I will elaborate more on this later in the chapter. Immediately after each lesson there was a collaborative reflection with the classroom teacher regarding the lesson, the mediation, learner's progress, group activity, etc., and I also reflected on my teaching as I perceived it later on the same day. I used the video material to confirm or supplement the observations and some of the notions from the reflections, by analysing the video material. I evaluated the programme by assessing learners' achievement according to their abilities to apply the thinking skills and processes and content knowledge to novel tasks successfully, their use of metacognitive awareness, and their use of vocabulary in different lessons. I also regarded the standard assessment of Curriculum 2005 as general guidelines, and triangulated it with the classroom teacher's perspectives and my own findings on what is considered as good performance. I was able to view my own teaching progress in six months over a two-year period through the video material and through my colleague's eyes. I could view a specific situation, assess it, address it with a specific solution, reassess it and decide if and whether the solution was good. All of these are manifestations of research practice, which I was not accustomed to, given my research background in the natural sciences. As the programme proceeded I was more and more comfortable with the techniques and their forms of analysis.

Teachers often complain that there is a separation between theory and practice, and that academic research is usually abstract and alien to them [(Hitchcock and Hughes 1995) p. 8]. I was able overcome this problem by learning to understand that research can take place within different paradigms. I became familiar with the discourses used in social science research and in contemporary educational discourses, and developed an ability to evaluate them critically. In doing so I made the theories part of my practice and part of my intellectual knowledge as a teacher and as a researcher. This enabled me understand what Whitehead (1993) wrote: 'It is through enquiring into our own practice that we are to create a living form of educational theory' [Whitehead 1993 in (McNiff *et al.* 1996) p. 11].

Action research is often said to be emancipatory and liberating for the teacher-researcher as well as for the participants in the research [(McKernan 1991) p. 33, (Hopkins 1993) p. 35]. In this context emancipation refers to the process involved in liberating teachers from a system of education that denies individual dignity by returning to them some degree of self-worth through the exercise of professional judgement [(Hopkins 1993) p. 35]. Teachers must not be 'content to be told what to do or being uncertain about what it is one is doing, teachers who engage in their own research are developing their professional judgement and are moving towards emancipation and autonomy.... It's liberating or emancipatory because it encourages independence of thought and argument on the part of the pupil and experimentation and the use of judgement on the part of the teacher' [(Hopkins 1993) p. 35]. Being responsible and in charge of the curriculum design in terms of what is to be taught, in what way, why and how increased my sense of confidence as a teacher and a curriculum designer. Assessing and reflecting on the programme's effectiveness liberated me from being dependent on someone else's judgement, although I collaboratively reflected with the classroom teacher at times. I developed an ability to critically evaluate and judge what is considered as good teaching and better performance. The decision taken to employ specific approaches, being in charge of the research, what to look at and how to look at it, why and the knowledge gained provided me with a sense of confidence as a researcher. As I described before, my experience of professional growth as a teacher, curriculum developer and as a researcher who evaluated the intervention programme that I implemented, resonates very strongly with Hopkins' sentiments.

I cannot assess fully yet the empowerment that the learners had experienced or even if they did at all – since I spent a short period of one term with them. However, I believe that I helped them develop a better use of thinking skills and processes, which in turn might help them shape their ability to think and take decisions for themselves. I encouraged them to solve their problems on their own, but provided them with strategies to do so, as well as encouraged them to check their work. Although many reported that they do not check their work by themselves, I believe that constant encouragement to become independent learners is the only way for them to develop into autonomous learners. I believe that the type of teaching used and the practice the learners had experienced is part of a long process towards autonomy and independent thinking and learning. This will be regarded as taking the right steps towards the emancipation of the learners to become better thinkers and people who are able to take responsibility for their own lives.

To summarise, gains in knowledge of social science research, cognitive development, science and special education, and a change and development in practice are part of the professional growth I had experienced. Steps towards the emancipation of the learners and the empowerment they might have experienced, as well as my own liberation as a result of self-development, intellectual development and the development of a critical stance as a teacher-researcher are all pertinent to action research.

5.3.2 Collaborative Gains

Teaching is usually one person's role. Generally, in most scenarios, the teacher is the one who takes decisions and manages the teaching-learning situation on his/her own. It is quite rare that colleagues or inspectors are present while the teacher practises his/her work. It is quite a private thing, in the sense that the interaction between the teacher and the learners is often distracted and different when another person is present. Therefore, observation of the teaching-learning situation is quite problematic. Even very experienced teachers testify that outsiders affect the interaction between them and their learners, and that their teaching style changes a bit. Kelly makes the point that 'people being observed usually start behaving differently' [(Kelly 1999b) p. 379].

However, it is also fairly well established that teachers learn best from other teachers and take criticism most readily from this source [(Hopkins 1993) p. 83]. For example, I had a unique and fruitful experience having a colleague present in the classroom while I was teaching. I was privileged to have the classroom teacher present in my classes throughout two cycles of inquiry. In this regard, I was exposed to feedback on my teaching style and on all aspects of teaching for more than 5 months, over a period of two years. He offered me an experienced and critical mirror, which reflected on my teaching style and abilities, and also enriched me from his own experience, sometimes demonstrating to me other ways of teaching. I perceived the classroom teacher as making two main contributions to my professional growth as a teacher: mainly as an experienced colleague and sometimes as a tutor/coach.

Kemmis (1983) indicates that action research is 'most rationally empowering when undertaken by participants collaboratively, though it is often undertaken by individuals' [in (Hopkins 1993) p.44]. I believe that what Kemmis refers to by 'collaborative' is a group of a few participants carrying out a parallel investigation into their practice and coming back to report to the small group and gain insights from this process. In this sense I chose to carry out action research by myself, as I mentioned previously in the methodology section in Chapter 3. However, during analysis I realised that, although I was conducting this study by myself, both the classroom teacher and I benefited from our collaborative work.

The classroom teacher is a highly experienced science, language and mathematics teacher and has practised a mediational teaching style for a few years. His contribution to this study was through an ongoing praxis regarding my teaching style and some mediational aspects of it, like bridging, questioning and challenging learners' answers. As trust developed between us, he offered me alternative solutions to teaching-learning situations, introducing frequent group discussion or pair discussions, and finding alternative ways to explain an idea. We used to reflect after every lesson and between lessons over the phone, and in some of our conversations he revealed some information about the learners and the ways they may learn better. Apart from one or two occasions, he acted as if he was not present in the lesson, letting me handle the learners and teach according to what I considered to be good practice. From time to time, mainly during the second cycle of inquiry, he asked my permission to interfere and reminded the learners of a specific principle or other activity they had used elsewhere. On one particular occasion he offered his skills to consolidate a point: when I explained the principles of categorisation, some learners had difficulties to pronounce the term fluently, including myself. He clapped his hands in a rhythm and all of us practiced saying the word a few times. It was a break in the lesson, which allowed the learners to move around a bit and relax as well as create a sense of strong involvement again. As Hopkins claims, practice can only be improved in the context in which it normally occurs and individuals need the support of colleagues as they seek to develop their practice [(Hopkins 1993) p. 84]. I learned from his experience as a teacher and also from his comments about my own teaching through our reflection. In this respect he observed my lessons and helped me shape my own teaching style.

Side by side, though unconsciously, during the second cycle of inquiry more and more evidence started to accumulate indicating his readiness to use IE and some of the processes and skills I was using in the science lesson. For example, he reminded them of the six-steps to planning when he needed their co-operation in decorating the classroom as a Japanese hall for international day. He told me later that this approach worked for him better than ever, and that it created an organised planned action, which the learners could follow easily and effectively. He also told me that he realised that he can use this approach on every task in any context. Indeed, just recently he was offered a job overseas and asked me if he could present the things I designed for the cycles of inquiry as part of his abilities to teach learners with special needs. It appears that he has realised that this type of material and knowledge are effective ways to teach science and possibly other subject matter. The point I want to make is that, unintentionally, our collaborative work, which was mainly aimed to reflect on my teaching and on the effectiveness of the intervention programme on the learners, had an additional value: it also contributed to the development of the classroom teacher. Even if only as an unintentional outcome of this study, this notion is interesting and exciting. At this point I can reflect on my study and redefine it, in Kemmis words, as a form of collaborative action research, or in Pamela Lomax's word about action research:

> Action Research is a way of defining and implementing relevant professional development. It is able to harness forms of collaboration and participation that are part of our professional rhetoric, but are rarely effective in practice. It starts small with a single committed person focusing on his/her practice. It gains momentum through the involvement of others as collaborators. It spreads as individuals reflect on the nature of their participation and the principle of shared ownership of practice is established. It can result in the formation of self-critical community, extended professionals in the best sense of the term.
> [Lomax 1990, in (McNiff *et al.* 1996) p.11]

5.3.3 Videotaping as a Method to Observe and Reflect

I often have mentioned throughout this study the advantage of being able to go back and view the lessons using the video material I produced. I would like to use this opportunity to stress the important role this video material played in my study. Since I was teaching throughout the intervention programme in both cycles, the only way to observe the teaching-learning situation was by using videotape. It enabled me to view in retrospect the situation as it was.

Using a video camera as a way to capture situations is time consuming and can be expensive. I spent approximately 50 per cent more time on watching the videos than on taking them, but in order to use the video material as a tool I transcribed all the lessons. This, in turn, is time-consuming work and it took me about 3-4 hours to transcribe 1 hour of lesson material; Plowman (1999) makes allowance for 20 (!) hours of labour [(Plowman 1999) p. 5]. However, these devices served effectively as a way to become familiar with the data, being able to quote learners' explanations as they expressed it in the lesson, and to evaluate different aspects of the learning teaching situation.

As a teacher in the classroom I perceived a slightly different picture of the learning-teaching situation when compared with the actual situation as it appeared via the videotapes. While I was teaching I was framed in my own thoughts or ideas regarding the lesson content and the skills and processes for the specific lesson, which obviously interfered with the ability to judge the lesson as a whole or a particular incident in it. My feelings and perceptions came out strongly in the reflection on the lesson I held immediately after the lesson ended, and these were sometimes very different perceptions to what actually occurred in the lesson. The video in this respect provides a more neutral perspective, which served as a way to triangulate my own reflection on the situation and allow me to evaluate it better. On a few occasions, in which I thought I explained or mediated a point in a certain way, the video material revealed a different scenario. Watching the videos allowed me to listen again to my own explanation and judge it, or look at my opportunities and quality of mediation, which in turn affected the planning of the next lesson. It allowed me to review any situation and identify the origin of the problem(s). Hopkins (1993) summarises the use of the video as a way to obtain visual material of the total teaching situation writing: 'It allows the teacher to observe many facets of her teaching, and provides an heuristic and accurate information for diagnosis.... And means of examining in detail specific teaching episodes' [(Hopkins 1993) p. 132]. The video can serve as a tool to evaluate and triangulate other observations, like the classroom teachers' observation and my own reflection.

Another advantage was the ability to collect and record the learners' responses to as many aspects as I wanted in the teaching-learning situation. I could first observe the lesson as a whole and then look for specific elements I was interested in. For example, use of thinking skills and processes, critical dialogues, metacognitive thinking, vocabulary use, learners' insights and learners' enthusiasm, their opinions, their movement in the classroom and in their places, what happens behind my back (!) and so on. Here the video material served as a tool to evaluate learners' achievements and manifestation of processes and skills as well as knowledge. Moreover, since the lessons are all captured on videotapes, I will be able to look for other possible elements of the learning-teaching situation, which I haven't looked for yet, in the near or more distant future.

A third advantage of the video material was the ability to go back and check particular incidents, for example, opportunities to mediate or bridge. In this regard I used the video material as a tool to learn from situations, as I was watching them over and over. It raised questions regarding my teaching, which I could then discuss with the IE trainer, the classroom teacher or my supervisor. I could plan a better response to the situation by formulating a specific question, which may lead to metacognitive awareness, providing some mediation, or challenging a particular learner in a similar situation. It provided me with the rare opportunity to see myself teaching, my facial expressions and mimics, my change of intonation, my movement around the class, the way I explain, the way I discipline, the ways in which I am a teacher. It is a mirror without an opinion or criticism, but rather the plain reality as it appears through the lens. The video material provided a possibility for assessing my own teaching abilities and style, which I personally enjoyed and learned from as a teacher and as a person.

All of these were later translated into the ability to interpret and evaluate the effect of the intervention programme across two cycles of inquiry. Not only that, but it also enabled me to gain a more holistic perception of the teaching-learning situation and the main role-players in it.

Apart from being time consuming, using the video camera has one major drawback. It may have a distractive effect on the learners, which I experienced with one learner in the first cycle and with two in the second cycle. For most learners the camera became unimportant after a few minutes and they tended to forget all about its presence. This became especially evident when I turned my back to face the white board...many of the learners did not realise that I would be able to observe their behaviour at these specific moments.

However, there were a few learners who remained conscious and aware of the camera's presence in the classroom and were probably distracted by it. Though I cannot confirm this, I assume that it affected their ability to concentrate and further benefit from the lesson. The camera was situated in the front, since it was important for me to see most of the learners' faces, as well as to hear properly what they had to say. If the camera had been situated differently – say, for example, at the back of the room –, it may have reduced the effect on these learners and they might have benefited more from the lesson. Nevertheless, I believe it was a compromise I had to make in order to allow the high input the video camera provided by being situated the way it was.

I made extensive use of the video material and definitely plan on using it often as a teacher throughout my career, and I strongly recommend the use of it for any similar purposes.

5.4 Praxiological Discussion on South African Policy

I will use this opportunity to link some of the study's findings with the current policies of South Africa regarding teaching in a process-led approach in the Natural Sciences Learning Area, as it appears in Curriculum 2005, which was recently revised (2002). Furthermore, I will consider some aspects regarding learners with special needs and the Inclusive Education Policy.

5.4.1 Emphasis on Process - Skills and Transferability

South Africa's Revised National Curriculum Statement RNCS (2002) specifies 7 critical outcomes and 5 development outcomes, which learners are expected to manifest and possess by the time they exit the educational system. In each of 8 learning areas, which include the Natural Sciences Learning Area, the RNCS specifies some learning outcomes, which are in line with the critical outcomes. Relevant content knowledge which the learners must know as part of their background knowledge as citizens, according to the RNCS (2002), is also included. The Natural Sciences Learning Area, under the RNCS, includes some processes and skills the learners must acquire and the standard assessment criteria specify how they should be manifested by the learners. These processes and skills, it is claimed in the document, serve as a means for critical and rational thinking and can serve the individual in his future life. The Natural Sciences Learning Area of Curriculum 2005 stresses that:

> The teaching and learning of science involves the development of range of process skills that may be used in everyday life, in the community and in the workplace. Learners can gain skills in an environment that supports creativity, responsibility, and growing confidence. Learners develop the ability to think objectively and use verity of form of reasoning while they use process skills to investigate, reflect, analyse, synthesis and communicate. [(Department of Education 2002) p. 4]

This statement implies that process skills can be acquired through intentional instruction in science and that they will be available to use, or be transferred to other situations in life (like in the workplace or in the community). Furthermore, it implies that these process skills will be manifested as a means of attaining objectivity, rationalism, synthesis and analysis.

The RNCS suggests that the skills and processes can transfer, but does not explain how teachers and educators will be able to achieve this, nor does it raise any doubt that it will actually happen. From my experience, though I invested time and effort to teach thinking skills and processes, and it appears that transfer to other learning areas had occurred to some extent, it is still difficult to demonstrate transferability.

Transfer can happen under specific conditions, as I discussed earlier in this chapter. However, even if the conditions are followed and present, namely that transfer is taught explicitly and the applications are similar to the original context where the skills or processes were taught, there is no guarantee that transfer will take place. It is a possible outcome; however, this depends strongly on the effort made to achieve transferability and on the type of background and skills that learners have [(Feuerstein and Feuerstein 1991) p. 9-11]. Feuerstein emphasised that the ability to teach and develop thinking skills and processes depends on human mediators. He stressed that 'the extent of cognitive modifiability is a function of the investment the educator is willing or able to make' [(Feuerstein *et al.* 1981) p. 273].

Taking into consideration the likelihood of transfer to occur, as this is published in the literature and as it transpired from my study, the SA Policy document's implication of the transferability of thinking skills and processes to everyday situations should be stated with more caution, in my view. The intention to teach skills and processes, and the possible transfer of these to everyday life, should definitely be in the minds of educators and teachers. However, transfer of thinking skills and processes depends strongly on various conditions, and in practice is not always present. It might be misleading to imply that it will become part of the repertoire of behaviours manifested by the learners as they exit the educational system. It may be too simplistic to suggest that by learning these processes and skills in the science learning area, transfer will be manifested later as a possible outcome of the curriculum.

The point I want to make is that, as educators and teachers, we must strive for the acquisition of thinking skills and processes by our learners, but also realise that the transferability of thinking skills and processes to other learning areas is complex and not an immediate or automatic result of teaching. Moreover, thinking skills and processes can eventually become means of critical thinking or rational thinking, but need to be bridged and practised first. And finally, the whole process involves long investment from the teacher's side, which does not necessarily happen by chance, as the literature suggests, nor as a by-product of traditional teaching [(Feuerstein and Feuerstein 1991; Kozulin and Presseisen 1995; Millar 1989; Wellington 1989)].

The latter arguments might have some implications regarding the South African Policy for the Natural Sciences Learning Area. If transferability is to be remotely realisable, a few adjustments to the Revised Natural Science Curriculum Statement might have to be made. For example, I think it might be a good idea to offer some guidance and means (including specific examples), as this study suggests, by which teachers will realise what the conditions are that make transferability possible, and how they might increase the likelihood of transfer of thinking skills to other learning areas. Second, it might have some implication for teacher education policies, both in pre-service and in-service training. To mediate the importance of bridging, and exercise it in order to increase transferability, may require a great deal of time and money that would need to be invested in preparing pre-service and in-service programmes for natural sciences teachers and implementing these programmes. Both aspects – training and guiding – may allow transferability of thinking skills and processes to other learning areas, and possibly become part of the general critical thinking and rationalism of learners, but this depend strongly on motivation, effort and mediation from the science teachers.

5.4.2 The Inclusion Policy

South Africa's new policy (1997) regards all learners as equal and follows an inclusive policy, which is supposed to provide learners, including learners with special needs, with an educational system that will suit their needs, whatever these may be. In the near future most learners will attend one mainstream school, which will be able to provide facilities that learners with special needs and other learners may require. The alternative school facilities will cater for much more severe cases of special education, which cannot be met in mainstream schools.

I have been teaching in the private school Pro-Ed for learners with special needs, which served as my context for both cycles of inquiry, and where I introduced the intervention programmes to teach science thinking skills. This school, according to the new system, will probably cater for more severe cases of disabilities and difficulties in learning in the future than for the kinds of learners who attend the school currently.

I taught in small classes of 11-12 learners and adjusted the mainstream curriculum and also selected exercises from Instrumental Enrichment instruments to suit my needs. All the material I used was in line with the intervention programme's intention to emphasise and consolidate the principles of thinking skills and processes first and then bridge these to science learning areas, as I described earlier in the chapter.

In general, I tried to provide the type of instruction which would characterise any good teaching. For example, Bell (2002) indicates that learners with special needs can benefit from the inclusion of science in their education. He specifies the appropriateness of 'hands-on' science, the implications of constructivist approaches to learning, and scaffolding as a tool for teachers to use in creating opportunities for children to engage with new ideas [(Bell 2002) p. 158]. Without mentioning mediation, he refers to 'recognising children's existing ideas, asking appropriate questions, selecting material and equipment, using worksheets and developing process skills by making their steps explicit [(Bell 2002)]. Moreover, Bell stresses the need to adapt our teaching strategies, often in small but significant ways, in order to meet the learning needs of individuals and groups of children [(Bell 2002) p. 161]. I implemented similar approached with both Grades 5 and 6.

Bancroft (2002) indicates that using multi-sensory teaching approaches and science investigations provides opportunities for practical work, allows usage of preferred representation of stimuli, which are particularly helpful to learners with learning difficulties [(Bancroft 2002) p. 169]. Specifically, in her activity planning, Bancroft included opportunities to develop process skills in promoting self-awareness, working with others, decision making, choosing strategies and taking on responsibility. She adapted a specific curriculum to learners with special needs by first analysing the possible barriers for their abilities, then simplifying terms and names, and using role playing and apparatus to model the context. Also, she considered possible problems in numeracy and literacy and addressed them accordingly. I find that Bancroft sometimes lowered her expectation of the learners and, instead of providing them with mediation and support to gain the background knowledge they required, she provided different shortcuts or other solutions, which I personally disagree with. These basic skills and background knowledge can be mediated to learners with special needs and unless we mediate the skills and knowledge, we maintain the learners' ignorance or lack of skills as is, instead of helping the learners overcome these gaps. Nevertheless, the special intervention programme characteristics she provides to learners with special needs, is similar to what I implemented and also parallel to mainstream curricula.

Learners' response to my intervention programme and the teacher's point of view regarding the suitability of the intervention programme to these learners (based on questions in interviews regarding the learners' enjoyment as well as the suitability of the programme to their needs), indicated that the intervention programme was suitable for the learners both in Grade 5 and 6. This is in line with what Scruggs, Mastropieri, Bakken and Brigham (1993) indicate, namely that 'when students (with learning difficulties) were taught by experimental, more indirect methods, they learned more, remembered more and enjoyed learning more…' [in (Bell 2002) p. 157].

I was providing science instruction, which I adapted to the learners' abilities and embedded teaching thinking skills and processes explicitly, with the differences of employing the use of IE instruments and the mediational teaching style. Since I was teaching the intervention programme to two small classes (in which it worked very well), I cannot confidently suggest that it would suit other learners with a different range of abilities. However, I do not see a reason why it would not contribute to the development of learners with wide range of abilities.

The privilege of working in small groups and being able to invest more time in each learner is obvious and does not need any justification. However, it does raise questions regarding the inclusion policy. Is it really possible to identify specific functions or dysfunctions when the classes are big and heterogeneous? Would these learners receive the same quality of education in mainstream education as I was able to provide to them in the small class? Can each of their unique problems, their background, origin and complexity be attended to as well as they could be in the small classes and intimate environment that were available in this instance?

The inclusive approach was developed to respond to some of the discrimination that learners with special needs might face. Classification and labelling, deprivation from ''normal'' social interaction and stigmatising are problematic and a complex reality that learners with special needs sometimes confront. However, can mainstream schooling provide as good an education as the alternative system (referred to as 'exclusive systems') might provide? Is it a good enough solution for these learners who have difficulties in learning and might be behind their peers?

Vygotsky stresses that special education is the only way to fully develop higher psychological functions in learners with learning disabilities. He writes: '...it should be a special system that employs its specific methods because handicapped [*sic*] students require modified and alternative educational methods' [(Gindis 1995), p. 79]. Furthermore, he explains that the learning environment should supply learners with special needs with the means to develop psychological tools that are most appropriate to compensate for their particular disability. The system should provide the learners with specially trained teachers, a different curriculum (without lowering expectations of what the learners can achieve), special technological auxiliary means and simply more time to learn [(Gindis 1995), p. 79].

Feuerstein believes that learners with special needs can overcome dysfunctions. He stresses that it depends on the willingness of the teacher-mediator to invest time and effort in the learners and specifies that 'there is no reason to believe that...low cognitive performance is an irreversible or immutable condition... (it) may be reversed by provision of appropriate Mediated Learning Experience [(Feuerstein *et al.* 1981), p. 273].

Learners with special needs manifest a variety of problems and difficulties. Radatz (1979) mentions only some of them: inadequate coding and decoding of knowledge and new information, use of meaningless strategies made up by students to solve problems, or use of inappropriate strategies [(Arbitman-Smith and Haywood 1980) p. 52]. These may affect scholastic achievements in general, and the transferability of thinking skills, problem-solving abilities and retrieval of knowledge in a particular subject matter. In this regard Bloom's (1976) claim is that 'when slow-learning students are not provided with the special academic skills they need to catch up with the class, they fall even further behind their classmates with regard to learning ability, rate of learning, and motivation for further learning' [(Arbitman-Smith and Haywood 1980) p. 52]. Haywood (1997) indicates that 'these children (learners with special needs) find it extraordinarily difficult to learn the content of the usual [*sic*] school curriculum because they have not acquired the cognitive tools with which to learn the content [(Arbitman-Smith and Haywood 1980) p. 54].

All of these claims imply that special attention, different teaching style and emphasis on thinking skills and cognitive development are only part of what learners with special needs might require. It might be difficult to supply and provide these learners with what they need to cope in a mainstream classroom.

In 1992 Hornby published a review of the inclusion education movement in the United Kingdom and the USA. He found that the inclusion theory has gone further towards integration than was apparently intended by legislation in either country. He specifies that there were specific criteria to guarantee suitable learning environments, which were supposed to be followed before a learner with special needs would attend a mainstream school. However, there were policies that involved progression towards the inclusion of *all* learners with special needs to local primary and secondary schools [(Hornby 1992) p. 131 (italics in the original text)]. He also mentions in his conclusions that there was a lack of research evidence in support of the effectiveness of integration for children with special needs in ordinary schools [(Hornby 1992) p. 133]. Moreover, he indicated that originally the sources for support inside mainstream schools, such as specialists and teachers for learners with special needs, were funded and trained; however, this has changed and the ordinary schools cannot meet the needs of these learners any longer; that the education provision for learners with special needs 'has changed for the worse' [(Hornby 1992) p. 133].

This criticism is also confirmed today, for example, by Wilson (1999), who stresses that 'Schools should not write off those who are not talented or competent. We need to start with the question "What sorts of worthwhile learning activities actually suit what type of pupils?" Clearly this would have to be worked out sensitively and in detail, but nothing is gained, indeed much is lost, by advancing the rhetorical ideology of "inclusion" ...simply putting all pupils in the same school is nowhere near the answer' [(Wilson 1999) p. 111-112].

Not that providing learners with special needs with suitable education in mainstream is not possible, but it requires well-organised facilities, administration and logistics, which are not necessarily easy to come by in the majority of South Africa's current mainstream classrooms/schools. According to Donald (1997), in many areas in South Africa mainstreaming occurred as a default solution rather than as an intentional implementation of the policy, since there was no other alternative schooling. However, the supporting facilities and resources were not necessarily available [(Donald *et al.*

1997) p. 237]. They might be provided in the future; however, this requires great adjustment and may not necessarily bring about the same type of results as I have experienced. If South Africa adopts the inclusive education approach, these issues must be well thought through and attended to. The policy makers must make sure that the advantages of mainstreaming will be higher than the price learners with special needs may pay because of changes in the policy. Furthermore, if inclusion is the answer, it might be recommended that teachers undergo extensive training to become better mediators, and possibly adopt the IE intervention as well, so that teachers will be able to address the special needs of some of their learners, as well as provide a teaching style which is suitable for their needs.

Practically, as a direct result of my study, it seems to me that the mediational style of teaching is suitable for learners with special needs who attend mainstream schools, but might also be suitable for other learners as well. Theoretically, I cannot see a reason why this style of teaching would not be suitable for mainstream learners with a wide range of abilities. It might be that the class size might affect the rate of learning, but it does not seem to me that it would decrease motivation or damage learning abilities. It seems to me that it cannot interfere with progress, but rather initiate and enhance learning and development.

Arbitman-Smith and Haywood criticised the remedial programmes for learners with special needs almost 20 years ago, saying 'with such deficiencies recognised by various theorists as occurring commonly in LD (learning disabled) students, one wonders why the emphasis in remedial programmes for LD students has not been on teaching cognitive skills all along' [(Arbitman-Smith and Haywood 1980) p. 55]. Since many educational systems adopted the inclusion policy, there is no specific curriculum for special education. Rather it is the same educational system, the same curriculum, etc. which is offered to all learners. South Africa recently integrated the process-led approach into Curriculum 2005, which is a way of addressing the development of cognitive skills. Nevertheless, it may be interesting to evaluate the situation of special education today with regard to teaching cognitive skills and processes in the alternative placement and the programmes carried out for learners with special needs inside the mainstream schools.

References List

- **Adams, D. L.** 1993 'Instructional Techniques for Critical Thinking and Life-Long Learning in Science Courses', *Journal of College Science Teaching* 23(4): 100-104.
- **Adams, M. J.** 1991 'Balancing Process and Content', in A. L. Costa (ed) *Developing Minds: Programs for Teaching Thinking*, Vol. 2, Alexandria, VA: Association for Supervision and Curriculum Development.
- **Altrichter, H., Kemmis, S., McTaggart, R. and Zuber-Skerrit, O.** 1990 'Defining, Confining or Refining Action Research?', in O. Zuber-Skerritt (ed) *Action Research for Change and Development.*, Brisbane: Griffith University.
- **Arbitman-Smith, R. and Haywood, H. C.** 1980 'Cognitive Education for Learning-Disabled Adolescents', *Journal of Abnormal Child and Psychology* 8(1): 51-64.
- **Ashman, A. and Elkins, J.** 1994 'Providing learning opportunities for all children', in A. A. a. J. Elkins (ed) *Educating Children with Special Needs*, Branswick, Victoria: Prentice Hall of Australia.
- **Babbie, E. and Mouton, J.** 1995 *Practice of Social Research*, Cape Town: Oxford University Press.
- **Babbie, E. and Mouton, J.** 2001 *Practice of Social Research*, Cape Town: Oxford University Press.
- **Bancroft, J.** 2002 'A Methodology for Developing Science Teaching Material for Pupils with Learning Difficulties', *Support and Learning* 17(4): 168-175.
- **Bell, D.** 2002 'Making Science Inclusive: Providing Effective Learning Opportunities for Children with Learning Difficulties', *Support and Learning* 17(4): 156-161.
- **Bernard, H. R.** 2000 *Social Research Methods: Qualitative and Quantitative Approaches*, Thousand Oaks, London, New Delhi: Sage Publications.
- **Best, J. W.** 1977 *Research in Education*, New Jersey: Prentice-Hall Inc.
- **Blanck, G.** 1990 'Vygotsky: The man and his cause', in L. C. Moll (ed) *Vygotsky and Education, Instructional Implications and Applications of Sociohistorical Psychology*, New York: Cambridge University Press.

- **Bransford, J. D., Burns, M. S., Delclos, V. R. and Vye, N. J.** 1986 'Teaching Thinking Evaluating Evaluations and Broadening the Base of Data.', *Educational Leadership.* 44(2): 68-70.
- **Cadle, J., Govender, J., Magi, T., Metcalf, T., Smith, D. and Van-Den-Berg, I.** 1995a *General Science 3*, Pietermaritzburg: Shuter & Shooter, LTD.
- **Cadle, J., Govender, J., Magi, T., Metcalf, T., Smith, D. and Van-Den-Berg, I.** 1995b *General Science 4*, Pietermaritzburg: Shuter & Shooter. LTD.
- **Carl, A. E.** 1995 *Teacher Empowerment through Curriculum Development: Theory into Practice*, Cape Town: Juta & Co, Ltd.
- **Chiras, D. D.** 1992 'Teaching Critical Thinking Skills in the Biology & Environmental Science Classrooms', *The American Biology Teacher* 54(8): 464-468.
- **Clacherty, A., Clacherty, G. and Esterhuysen, P.** 1998 *Science Spectrum grade 4.*, Cape Town: Maskew Miller Longman, LTD.
- **Cohen, L. and Manion, L.** 1994 *Research methods in education*, Forth Edition, London: Routledge.
- **Conners, C. K. and Jett, J. L.** 1999 *Attention deficit hyperactivity disorder (in adults and children): The latest assessment and treatment strategies*, Kansas City: Compact Clinical.
- **Costa, A. L.** 1991 *Developing Minds: programs for teaching thinking*, Vol. 2, Alexandria, VA: Association for Supervision and Curriculum Development.
- **Costa, A. L.** 2004 Components of a Well Developed Thinking Skills Program **http:/www.newhorizons.org/strategies/thinking/costa2.html**
- **Cotton, K.** 2000 'Teaching Thinking Skills': School Improvement Research Series. **http://www.nwrel.org/scpd/sirs/6/cu11.html**
- **Dawes, A. and Donald, D.** 1994 'Understanding the Psychological Consequences of Adversity', in A. Dawes and D. Donald (eds) *Childhood and Adversity: Psychological Perspectives from South African Research*, Cape Town: David Philip Publishers LTD.
- **de-Bono, E.** 1993 *Teach Your Child How to Think*, Jerusalem, Israel: The Branco Weiss Institute for Development of Thinking (in Hebrew).
- **Department of Education** 1997 'Curriculum 2005- Specific Outcomes, Assessment Criteria, Range Statements, Grades 1-9', Pretoria: Department of Education.

- **Department of Education** 2001 *White Paper 6: Special Needs Education: Building an Inclusive Education and Training System*. Pretoria: Department of Education.
- **Department of Education** 2002 'Revised National Curriculum Statement Grades 1-9 (Schools)', Pretoria: Department of Education.
- **Donald, D.** 1994 'Children with Special Education Needs: The Reproduction of Disadvantage in Poorly Served Communities', in A. Dawes and D. Donald (eds) *Childhood and Adversity: Psychological Perspectives from South African Research*, Cape Town: David Philip.
- **Donald, D., Lazarus, S. and Lolwana, P.** 1997 *Educational Psychology in Social Context*, Cape Town: Oxford University Press.
- **Durrheim, K.** 1999 'Research Design', in M. Terre-Blanche and K. Durrheim (eds) *Research in Practice : Applied Methods for the Social Sciences*, Cape Town: University of Cape Town Press.
- **Engelbrecht, P.** 2004 'Changing Roles for Educational Psychologists within Inclusive Education in South Africa', *School Psychology International* 25(1): 20-29
- **Feuerstein, R.** 1980 *Instrumental Enrichment*, Baltimore: University Park Press.
- **Feuerstein, R. and Feuerstein, S.** 1991 'Mediated Learning Experience: A Theoretical Review', in R. Feuerstein, P. S. Klein and A. J. Tennenbaum (eds) *Mediated Learning Experience (MLE), Theoretical, Psychological and Learning Implications*, London: Freund Publishing House LTD.
- **Feuerstein, R., Miller, R., Hoffman, M. B., Rand, Y., Mintzker, Y. and Jensen, M. R.** 1981 'Cognitive Modifiability in Adolescence Cognitive Structure and The Effect of Intervention.', *The Journal of Special Education* 15(2): 267-287.
- **Fisher, R.** 1990 *Teaching Children to Think*, Oxford: Basil Blackwell Ltd.
- **Frankenstein, C.** 1979 *They Think Again: Restoring Cognitive Abilities Through Teaching*, London: Litton Educational Publishing, Inc.
- **Franklin - Language Master,** 1987, Franklin Electronic Publishers, Inc., Model: LM-3000B Merriam-Webster, Inc.
- **Friedler, Y. and Tamir, P.** 1986 'Teaching Basic Concepts of Scientific Research to High School Students', *Journal of Biological Education* 20(4): 263-270.

- **Gindis, B.** 1995 'The Social/Cultural Implication of Disability: Vygotsky's Paradigm for Special Education', *Educational Psychologist* 30(2): 77-81.
- **Haywood, H. C.** 1987 'A Mediational Teaching Style', *The Thinking Teacher* 4(1): 1-6.
- **Haywood, H. C.** 1993 'A Mediational Teaching Style', *International Journal of Cognitive and Mediated Learning* 3(1): 27-38.
- **Head, G. and O'neill, W.** 1999 'Introducing Feuerstein's Instrumental Enrichment in a school for children with social, emotional and behavioural difficulties', *Support for Learning* 14(3): 123-128.
- **Heath, C. and Hindmarsh, J.** 2002 'Putting the research into theory: Analysing interaction: video, ethnography and situated conduct', in T. May (ed) *Qualitative Research in Action*, London: SAGE.
- **Hester, J. P.** 1994 *Teaching for thinking : a program for school improvement through teaching critical thinking across the curriculum*, Durham, North Carolina: Carolina Academic Press.
- **Hitchcock, G. and Hughes, D.** 1995 *Research and the Teacher: A qualitative introduction to school-based research.*, Second Edition, London and New York: Routledge.
- **Hobbs, N.** 1980 'Feuerstein's Instrumental Enrichment; Teaching Intelligence to Adolescents', *Educational Leadership* 37(7): 566-568.
- **Hoffman, M. and Feuerstein, R.** 1988a *Teachers' Guide to Categorization*: Hadassah-Wizo-Canada-Research Institute.
- **Hoffman, M. and Feuerstein, R.** 1988b *Teachers' Guide to Comparisons*: Hadassah-Wizo-Canada-Research Institute.
- **Hoffman, M. and Feuerstein, R.** 1988c *Teachers' Guide to Organization of Dots*: Hadassah-Wizo-Canada-Research Institute.
- **Hopkins, D.** 1993 *A teacher's guide to classroom research*, Buckingham, Buckinghamshire: Open University Press.
- **Hornby, G.** 1992 'Integration of Children with Special Educational Needs: Is it Time for Policy Review?', *Support and Learning* 7(3): 130-134.

- **Jenkins, E. W.** 1989 'Processes in science education: an historical perspective.', in J. Wellington (ed) *Skills and processes in science education: A critical analysis*, New York: Routledge.
- **Kanjee, A.** 1999 'Assessment Research', in M. T. Blanche and K. Durrheim (eds) *Research in Practice : Applied Methods for the Social Sciences*, Cape Town: University of Cape Town Press.
- **Karpov, Y. V. and Haywood, H. C.** 1998 'Two Ways to Elaborate Vygotsky's Concept of Mediation', *American Psychologist* 53(1): 27-36.
- **Kelly, K.** 1999a 'Calling it a Day: Reaching Conclusions in Qualitative Research', in M. Terre-Blanche and K. Durrheim (eds) *Research in Practice : Applied Methods for the Social Sciences*, Cape Town: University of Cape Town Press.
- **Kelly, K.** 1999b 'From Encounter to Text: Collecting Qualitative Data for Interpretive Research', in M. Terre-Blanche and K. Durrheim (eds) *Research in Practice : Applied Methods for the Social Sciences*, Cape Town: University of Cape Town Press.
- **Kemmis, S.** 1990 'Improving Education through Action Research', in O. Zuber-Skerritt (ed) *Action Research for Change and Development.*, Brisbane: Griffith University.
- **Kincheloe, J. L.** 2003 *Teachers as Researchers: Qualitative Inquiry as a Path to Empowerment*, London and New York: Routledge Falmer.
- **Kirkham, J.** 1989 'Balanced Science: equilibrium between context, process, and content.', in J. Wellington (ed) *Skills and processes in science education: A critical analysis*, New York: Routledge.
- **Klauer, K. J.** 2002 *A new generation of cognitive training for children: a European perspective. Learning Potential Assessment and Cognitive Training: actual research and perspectives in theory building and methodology.*, Vol. 7, Oxford: Elsevier Science Ltd.
- **Knight, B. A.** 1999 'Towards inclusion of students with special educational needs in the regular classroom', *Support for Learning* 14(1): 3-7.
- **Kochendorfer, L.** 1994 'Biology Teacher as Researcher', *The American Biology Teacher* 56(3): 135-137.

- **Kozulin, A. and Presseisen, B. Z.** 1995 'Mediated Learning Experience and Psychological Tools: Vygotsky's and Feuerstein's Perspectives in a Study of Student Learning', *Educational Psychologist* 30(2): 67-75.
- **Kuhn, D.** 1989 'Children and Adults as Intuitive Scientists', *Psychological Review* 96(4): 674-689.
- **Lazarowitz, R. and Huppert, Y.** 1980 'Developing Creative Thinking Skills in Secondary School Biology Students', *The American Biology Teacher* 42(4): 226-228.
- **Le Grange, LLL.** 2001 'Pedagogical Practices in a Higher Education Context: Case Studies in Environmental and Science Education' Didactic, Stellenbosch University.
- **Maykut, P. and Morehouse, R.** 1994 *Beginning qualitative research: a philosophic and practical guide*, London: Routledge.
- **McKernan, J.** 1991 *A Curriculum Action Research: A Handbook of Methods and Resources for the Reflective Practitioner.*, London: Kogan Page.
- **McMurray, M. A. and Beisenherz, P.** 1991 'Reliability and Concurrent Validity of A Measure of Critical Thinking Skills in Biology', *Journal of Research in Science Teaching* 28(2): 183-192.
- **McNiff, J., Lomax, P. and Whitehead, J.** 1996 *You and Your Action Research Project*, London: Routledge.
- **McPeck, J.** 1981 *Critical thinking and education*, Oxford: Martin Robertson.
- **McPeck, J.** 1990 *Teaching Critical Thinking*, New York: Routledge.
- **Messerer, J., E. Hunt, Meyers, G. and Lerner, J.** 1984 'Feuerstein's Instrumental Enrichment: A New Approach for Activating Intellectual Potential in Learning Disabled Youth.', *Journal of Learning Disabilities* 17(6): 322-325.
- **Miciikas, L. B.** 1996 'Designing a Biology Curriculum that Promotes Scientific Literacy', *Journal of College Science Teaching*: 431-434.
- **Millar, R.** 1989 'What is 'scientific method' and can it be thought?', in J. Wellington (ed) *Skills and processes in science education: A critical analysis*, New York: Routledge.
- **Moll, L. C.** 1990 'Introduction', in L. C. Moll (ed) *Vygotsky and Education, Instructional Implications and Applications of Sociohistorical Psychology*, New York: Cambridge University Press.

- **Moll, M. B. and Allen, R. D.** 1982 'Developing Critical Thinking Skills in Biology', *Journal of College Science Teaching* 12: 95-98.
- **Narrol, H., Silverman, H. and Waksman, M.** 1982 'Developing Cognitive Potential in Vocational High School Students', *Journal of Educational Research* 76(2): 107-112.
- **Neuwirth, S.** 1994 'Attention Deficit Disorder and Attention Deficit Hyperactivity Disorder', Vol. 2003: This article appeared in the Spring '97 GRADDA Newsletter, NIH Publication.
- **Newman, W. L.** 2003 *'Social Research Methods: qualitative and quantitative Approaches'*, Boston: Allyn and Bacon.
- **Norris, S. P.** 1985 'Synthesis of Research on Critical Thinking', *Educational Leadership* 42(8): 40-45.
- **Novak, J. A. and Dettloff, J. M.** 1989 'Developing Critical-Thinking Skills in Community College Students', *Journal of College Science Teaching* 19: 22-25.
- **Ormrod, J. E.** 1995 *Educational Psychology: principles and applications*, New Jersey: Prentice-Hall, Inc. A Simon & Schuster Company.
- **Park, T. and Cilliers, C. D.** 2002 'The Teaching of Thinking in Post-Apartheid South African Education System', in C. D. Cilliers (ed) *Educational Psychology: Cognitive Education, BEd*, Braamfontein: College Publications.
- **Plowman, L.** 1999 'Using Video for Observing Interaction in the Classroom' *Spotlights*, Vol. 2002: The Scottish Council for Research in Education. www.scre.ac.uk/spotlight/spotlight72.html
- **Potter, C.** 1999 'Programme Evaluation', in M. Terre-Blanche and K. Durrheim (eds) *Research in Practice : Applied Methods for the Social Sciences*, Cape Town: University of Cape Town Press.
- **Pro-Ed Broacher,** Corner of Elma & Erin roads, Rondebosch, Cape Town. proedhse@proedhouse.co.za
- **Republic of South Africa** 1995 'White paper on Education and Training', Pretoria: Department of Education.
- **Republic of South Africa** 1997 'White Paper on Integrated National Disability Strategy': Office of the Deputy President.

- **Rourke, B. P. and Del-Dotto, J. E.** 1994 *Learning Disabilities : A Neuropsychological Perspective*, Thousand Oaks, California: Sage Publication, Inc.
- **Scott, D. and Usher, R.** 1996 *Understanding Educational Research*, London: Routledge.
- **Screen, P. A.** 1986 'The Warwick Process Science Project', *School Science Review* 68(242): 12-16.
- **Shaw, T. J.** 1983 'The Effect of Process-Oriented Science Curriculum Upon Problem-Solving Ability', *Science Education* 67(5): 615-623.
- **Shayer, M. and Adey, P. S.** 1992a 'Accelerating the Development of Formal Thinking in Middle and High Schools Students II: Post-project Effects on Science Achievement', *Journal of Research in Science Teaching* 29(9): 81-92.
- **Shayer, M. and Adey, P. S.** 1992b 'Accelerating the Development of Formal Thinking in Middle and High School Students III: Testing the Permanency of Effects', *Journal of Research in Science Teaching* 29(10): 1101-1115.
- **Spady, W. G.** 1994 *Outcome-Based Education, Critical Issues and Answers*, Arlington: American Association of School Administration.
- **Statkiewicz, W. R. and Allen, R. D.** 1983 'Practice Exercises to Develop Critical Thinking Skills', *Journal of College Science Teaching* 12: 262-266.
- **Sternberg, R. J. and Bhana, K.** 1986 'Synthesis of Research on the Effectiveness of Intellectual Skills Programs: Snake-Oil Remedies or Miracle Cures?', *Educational Leadership* 44(2): 60-67.
- **Terre-Blanche, M. and Durrheim, K.** 1999 'Histories of the Present: Social Science Research in Context', in M. Terre-Blanche and K. Durrheim (eds) *Research in Practice : Applied Methods for the Social Sciences*, Cape Town: University of Cape Town Press.
- **Terre-Blanche, M. and Kelly, K.** 1999 'Interpretive Methods' in M. Terre-Blanche and K. Durrheim (eds) *Research in Practice : Applied Methods for the Social Sciences*, Cape Town: University of Cape Town Press.
- **Terre-Blanche, M., D. Van Veuren and A. Moree** 1999 'Research in Practice' in M. Terre-Blanche and K. Durrheim (eds) *Research in Practice : Applied Methods for the Social Sciences*, Cape Town: University of Cape Town Press.

- **Terrio, B.** 1992 *Witches, Ghosts & Goblin*, Lincolnwood: Publication International, LTD.
- **Vye, N. J. and Bransford, J. D.** 1981 'Programs for Teaching Thinking', *Educational Leadership* 39(1): 26-28.
- **Warsham, A. W. and Austin, G. R.** 1983 'Effects of Teaching Thinking Skills on SAT Scores', *Educational Leadership*(ov): 50-51.
- **Watson, J.** 2000 'Constructive Instruction and Learning difficulties', *Support for Learning* 15(3): 134-140.
- **Wellington, J.** 1989 'Skills and processes in science education: an introduction', in J. Wellington (ed) *Skills and processes in science education: A critical analysis*, New York: Routledge.
- **Wellington, J.** 2000 *Educational Research: Contemporary Issues and Practical Approaches*, London and New York: Continuum.
- **Wells, G.** 1999 'Dialogic inquiry: Towards a sociocultural practice and theory of education. The zone of proximal development and its implications for learning and teaching': New York: Cambridge University Press. Chapter 10.
- **Wilson, J.** 1999 'Some Conceptual Difficulties about 'Inclusion'', *Support for Learning* 14(3): 110-112.
- **Zeidler, D. L., Lederman, N. G. and Taylor, S. C.** 1992 'Fallacies and Student Discourse: Conceptualizing the Role of Critical Thinking in Science Education', *Science Education* 76(4): 437-450.
- **Zohar, A., Weinberger, Y. and Tamir, P.** 1994 'The Effect of the Biology Critical Thinking Project on the Development of Critical Thinking', *Journal of Research in Science Teaching* 31(2): 183-196.

Appendices

Appendix A

September 11 2002

Dear Dr. Worrall,

I request your permission to conduct my research in your school.
I am doing a master's degree in Curriculum Studies at the University of Stellenbosch under the supervision of Dr. Lesley le Grange. I developed a mini program in biology using the Instrumental Enrichment instruments. I had a preliminary conversation with Mr. Noel Carl as the teacher of the 6th grade and he is willing to cooperate with me in this project.

The purpose of the program is to teach specific thinking skills that were identified by the Commission on Science Education of the American Association for Advancement of Science (AAAS) and can be divided to two groups:

- Basic processes including observing, measuring, inferring, predicting, classifying and collecting and recording data.
- Integrated processes including interpreting data, controlling variables, defining operationally, formulating hypotheses and experimenting.

These processes are known to be representative of problem-solving activity (Gange in Shaw 1983).

20 lessons will be designed to introduce the different basic and integrated processes. The lessons will include exercises from IE instruments to practice the different processes explicitly, and then bridging the processes to biological and non-biological topics. Examples from biological topics as well as experiments will be conducted in the classroom followed by discussions and bridging them to everyday life. This will form part of the content. The content will be linked to the 6th grade SA curriculum (Solutions and Food and Feeding).

- A systematical approach to plan an experiment.
- Determine the objective: define the experimental goal.
- Look at what is given: gathering data.
- Decide on a strategy: hypothesis formation.
- Establish the rules or parameters: control, variables and repetition.
- Decide on the starting point: define the details of the experiment.

- Check whether the objective has been achieved: compare data to the hypothesis and conclude.

The Study will evaluate the program in terms of effectiveness of teaching thinking skills in biology. It will be an action research project whereby suggestions for improvements provided by evaluations of lessons in the program will be implemented in the next lessons to the benefit of the learners.

Children will be expected to use these thinking processes more efficiently, in biological contexts as well as bridging them to non-biological situations. The lessons will be recorded, may be videotaped, and tests and questionnaires will form part of data collection processes.

The results, with your permission, would be published in my master's thesis and also made available to your school.

Thanking you for your cooperation,
Sincerely yours,

Nilly Galyam
M. Sc. in Molecular Biology,
Teaching certificate in Biology Instruction,
M. Ed. student in Curriculum Studies.

11-09-2002

Dr A Worrall
Principal
Pro-Ed School

RE: MS GALYAM'S RESEARCH PROJECT

I hereby confirm that Ms Nilly Galyam is currently registered for the Master's degree in Education (Curriculum Studies) at the University of Stellenbosch. I also confirm that I am her supervisor for the thesis component of her degree.

Ms Galyam has an outstanding academic record and possesses the necessary research skills to complete her study successfully.

I trust that you will be able to accommodate her request to do her research at your school.

Best regards

Lesley LL Le Grange BSc (UWC) HDE (P/G)sec BA BEd MEd (UCT) PhD (Stell)

Fakulteit Opvoedkunde • Faculty of Education

Departement Didaktiek • Department of Didactics

Privaat Sak/Private Bag X1 • Matieland 7602 • Suid-Afrika/South Africa

Tel +27 21 808 2300 • Faks/Fax: +27 21 808 2295

http://www.sun.ac.za

4-Dec-02

Dear Dr. Worrall,

I would like to thank you for allowing me to conduct my research in Pro-Ed school. Given the opportunity, I ran a mini programme in science with Mr. Noel Carr 6 grade students, which will serve as the practical phase of my master degree in curriculum studies. The lesson design was accomplished in October under the supervision of Dr. Lesley Le-Grange.

Being able to work in small groups, with children that received mediated learning for quite a while, and having the privilege to have a close reflection after every lesson from Mr. Carr as the classroom teacher, as a college and as a friend, makes this practical work an extremely good experience for me as a teacher and also for the children.

Now, the analysis phase will take place followed by writing down my thesis. Attached is a summary of the mini programme, with the lesson details and examples of the different activities and quizzes that took place during this term. Most of the lessons and activities were videotaped, and the children completed 7 questionnaires (once a week) altogether. Please contact me if you wish to see or receive more information about any of the lessons or activities.

Wish you a happy New Year and a nice holiday,

Best regards,
Nilly Galyam

ngalyam@hotmail.com,
17 Le Coetzenburg,
7 Andringa St.
Stellenbosch,
021-8869696.

Summary of the mini programme:
Developing Thinking Skills in a Science using Instrumental Enrichment.

Conducted by Nilly Galyam under the Supervision of Dr. Lesley Le Grange.
University of Stellenbosch.

The purpose of this study was to find out whether and to what extent teaching science using IE instruments can:
1. Contribute to the development of thinking skills in science topics.
2. Contribute to the transfer of thinking skills to non-science disciplines.
3. Increase student engagement in science class.
4. Influence the classroom learning environment.

16 lessons were designed combining science curriculum for six grade students, with 11 thinking skills that were recognised by the Commission on Science Education of the American Association for Advancement of Science (AAAS). These skills are known to be representative of problem-solving activity and can also be used in every day life {Gange, 1970 in (Shaw 1983)}.

The basic processes included observing, measuring, inferring, predicting, classifying collecting and recording data while the integrated processes included interpreting data, controlling variables, defining operationally, formulating hypotheses and experimenting. Some of the lessons included exercises from IE instruments in order to practice and emphasise a specific skill. Examples from biological topics as well as experiments were conducted in the classroom followed by discussions and bridging to everyday life.

Lesson 1: Introduction to systematical approach using the first and third pages from IE-Organisation of Dots. 6 steps were thought as a systematical approach to any task. The steps were used as a plan to accomplish the tasks in organisation of dots. Mind maps were drown by the children and we hung posters with the different steps on the wall. Those were the steps.

- Define your goal.
- Gathering data.
- What strategy shall we use.
- Decide on a starting point.
- Establish parameters and rules.
- Check your work

Lesson 2: A systematical approach to plan an experiment. We used the different steps to plan an experiment that will answer the scientific question: how to increase milk production in cows. We did the bridging between the 6 steps of systematical approach to any task into the different steps that guide planning any experiment. The work of a scientist was discussed as well as the applications of science in everyday life. Topics such as cure to diseases, fundamental research, production and modifications in agriculture were discussed as well.

Lesson 3: Following instructions. In this lesson the children had to 'follow instructions' and the meaning and importance of this activity were discussed. The instructions we used served as introduction to laboratory equipment and first steps of experimenting.

Lesson 4: Measuring. In this lesson the usage of scales, measurement cylinder, meter etc. were used to measure different dimension and different units. The importance of accuracy when measuring was stressed, as a basic need when experimenting and when comparison between groups is required. A small quiz was done to check whether the children could come up with different strategies as part of the systematical approach to a specific problem in science.

Lesson 5: Observe and compare I. In this lesson the children practised their ability to compare, when describing similarities and differences between objects and figures, and seeking for different parameters for comparison. Pages from IE-Comparisons were used and then they compared different solutions when changing the amounts of the solutes and the solvents and observing the outcomes of it. (Change in colour, smell, taste, concentration, etc.)

Lesson 6: Compare II. In this lesson the concept of table and Venn diagram were discussed, and used as two strategies to describe the similarities and differences between solutions and objects. A small quiz was done to check whether the children could use systematical approach to plan an experiment.

Lesson 7: Factors. The importance of changing only one factor at a time, in any experiment was discussed through stories, and bridged to science context. We experimented with different factors such as the amount of solute and solvent to learn more about the cause and effect of changing one or more factors at one time.

Lesson 8: Planning and conducting an experiment: how to affect solubility. In this lesson integration of the first 8 lessons was done step by step to plan an experiment to check out what affects solubility. The children had to follow the steps and come up with a plan to check the influence of heat and stirring on solubility of salt. Identification of the different factors involved and the usage of a Venn diagram were checked out in a small quiz.

Lesson 9: Infer. The topic of the next lessons was food and feeding. We discussed the different signs of life: the need for air, food, water, the ability to move, to get rid of waste, to reproduce and to respond to the environment. We practised gaining meaning indirectly through cues and evidence that will lead us to conclusion.

Lesson 10: First outing: we went to Rondenbosch common and spent the time there, collecting and recording different organisms. Safety instructions were given and conservation rules were discussed. Insects and other invertebrates were collected by the children, identified and some of their characteristics were discussed.

Lesson 11: Classification I. Exercises from IE-Categorisation, as well as general classification of all things in the world were practised. We have used hierarchical diagram as a strategy for classification. Different dimensions of classification were used, and the 5 different kingdoms of organisms were introduced.

Lesson 12: Classification II. Exercises from IE-Categorisation were used to classify shapes according to size and colour. Principles of how to classify and why is it important were discussed. Introduction to the different feeding habits of herbivores, carnivores and omnivores was thought as well.

Lesson 13: Classification III. The topic of this lesson was different classifications in nature: taxonomy of animals, categorisation of vegetables into different plant parts, the differences between a browser and a grasser, etc. the children were using hierarchical diagram to classify these items.

Lesson 14: Revising skills and planning an experiment. In this lesson all the different skills that we learnt were revised and the children brought examples from different lessons. Then they planned an experiment to change the colour of a black rhino into a white one (their suggestion!), using the steps of systematical approach to plan this experiment.

Lesson 15: Second outing to Rondenbosch common, experimenting the feeding habits of an insect. Each of the children caught an insect and planned an experiment to check if it is a herbivore, carnivore or an omnivore. By introducing different types of food (the factor we changed) and observing the outcome. While we were waiting for the insects to eat the children transferred words and skills they have learnt using pantomime and as drawings part of revision.

Lesson 16: Third outing to the aquarium. A teacher from the aquarium gave a lesson on the two oceans of South Africa as well as about some invertebrates in the sea. Then the children were looking for specific animals in the aquarium while completing a work sheet. The tour included two feeding exhibitions in the aquarium.

Lesson 17: In the last lesson, the children had written a quiz summarising some of the skills that were thought, and then an open reflection on the different topics and skills took place, as a way to assess the effectiveness of this programme.

31-Mar-03

Dear Dr. Worrall,

I request your permission to conduct an extension to my research in your school. I am doing a Ph D. degree in Curriculum Studies at the University of Stellenbosch under the supervision of Prof. Lesley le Grange. I developed a mini program in science using selected IE instruments and after implementing and evaluating it successfully last year I would like to try and improve it by implementing some of my findings. I had a preliminary conversation with Mr. Noel Carl as the teacher of the 5th grade and he is willing to cooperate with me in this project.

The purpose of the program is to teach specific science thinking skills that were identified by the Commission on Science Education of the American Association for Advancement of Science (AAAS) and can be divided to two groups:

- Basic processes including observing, measuring, inferring, predicting, classifying and collecting and recording data.
- Integrated processes including interpreting data, controlling variables, defining operationally, formulating hypotheses and experimenting.

These processes are known to be representative of problem-solving activity (Gange in Shaw 1983).

18 lessons will be designed to introduce some of the basic and integrated science processes. The skills will be embedded in the science curriculum for grade 5 and will include the science topics: solutions and reproduction.

The Study will evaluate the two cycles of inquiry of this program in terms of effectiveness of teaching thinking skills in science. It will be an action research project whereby suggestions for improvements provided by evaluations of lessons in the program will be implemented in the next lessons to the benefit of the learners.

Children will be expected to use these thinking skills more efficiently, in scientific contexts as well as bridging them to non-scientific situations. All lessons will videotaped, tests and questionnaires will form part of data collection processes.

The results, with your permission, would be published in my Ph D thesis and also made available to your school.

Thanking you for your cooperation,

Sincerely yours.

Nilly Galyam

M. Sc. in Molecular Biology,

Teaching certificate in Biology Instruction,

Ph D. student in Curriculum Studies.

PROED HOUSE
PRO ED CENTRE

FOR THOSE WHO LEARN DIFFERENTLY

c/o Erin & Elma Roads Rondebosch 7700 Cape Town · Tel. +27 2 686 1567 · Fax. +27 21 686 1679 ·
www.proedhouse.co.za - email. proedhse@proedhouse.co.za

11th April 2003

c.c. Ms Nilly Galyam

Professor Lesley LL Le Grange
Faculty of Education
Department of Didactics
Private Bag X1
MATIELAND
7602

Dear Professor Le Grange

Re: MS GALYAM'S RESEARCH PROJECT

Thank you for your letter of the 2nd April 2003 regarding Ms Nilly Galyam's research project.

It will be with pleasure that we accommodate her at our school in order to obtain research data.

She has proved to be very helpful and accommodating when previously with us and we look forward to having her and learning about her research.

Sincerely

Anita Worrall

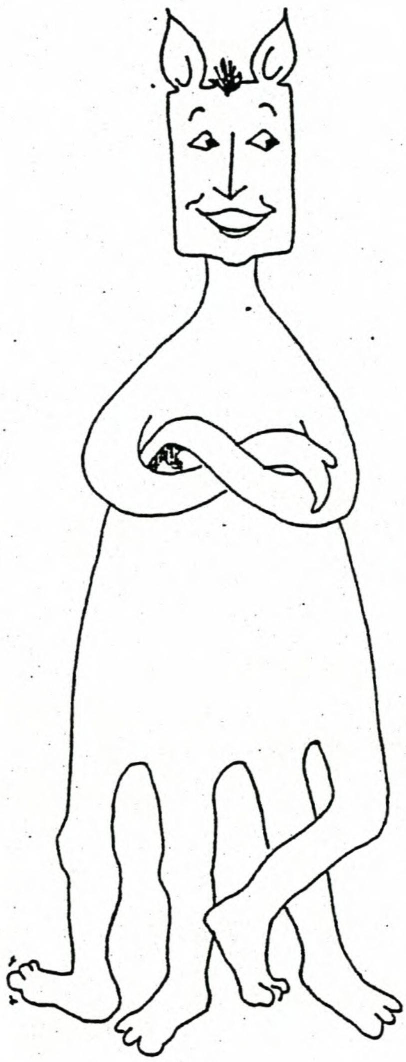
DR ANITA WORRALL
Psychologist / Director
BA Hons (McGill Canada) MA PhD (Cornell USA) Dipl Sp Ed (Canberra Austr)

Appendix B

Observing Differences

Instructions: Observe the creatures in order to identify pairs of characteristics.

What is the Same?
What is different?



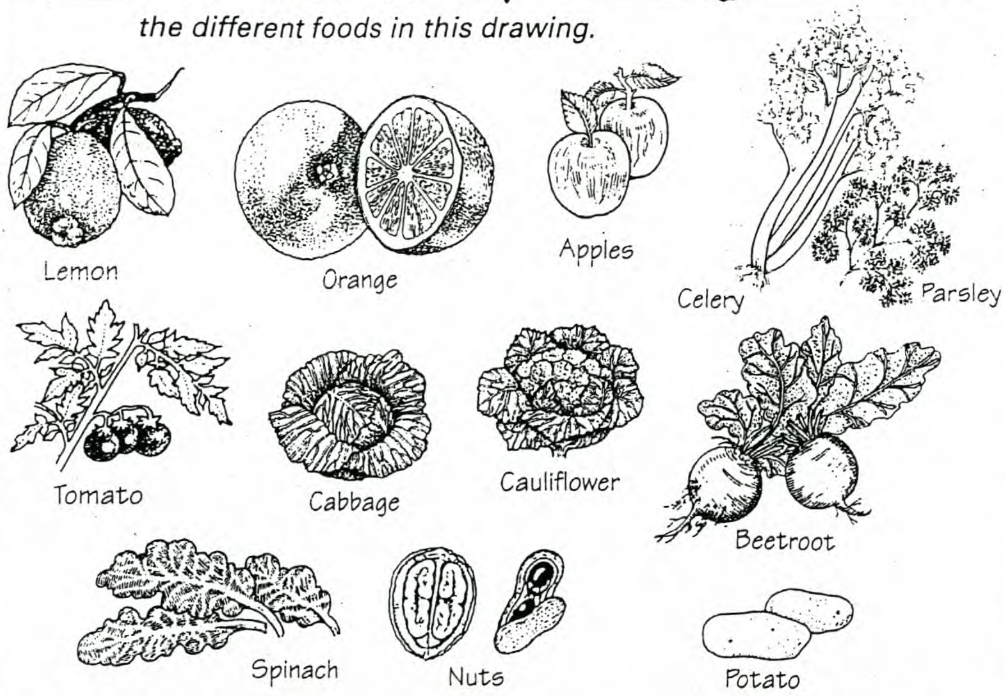
ONO

APA

From Odyssey: A Curriculum for thinking

TALK ABOUT . . .

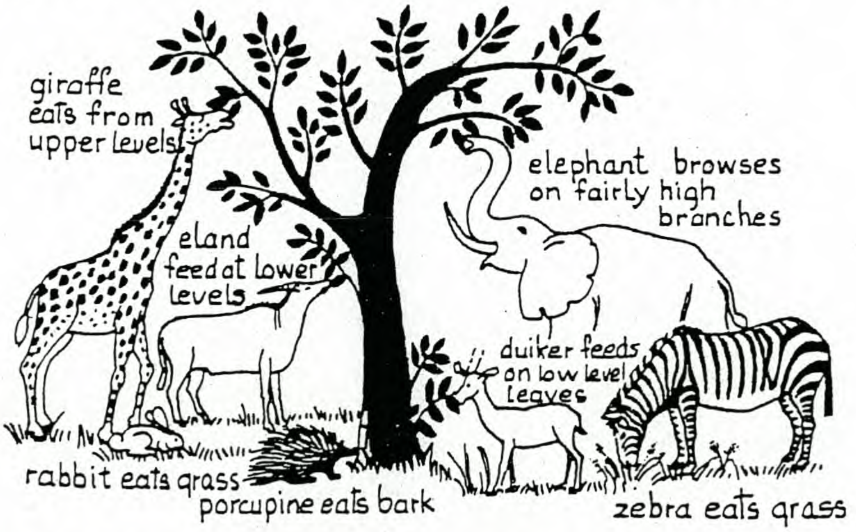
the different foods in this drawing.



Group these foods into roots, stems, leaves, flowers, fruits and seeds.

lerbivores that eat leaves, twigs, bark, flowers, fruits and seeds from shrubs nd trees, are called **browsers**. The animals which eat grass are called **grazers**.

Let us now take a closer look at some animals in their natural habitat. Study this drawing which shows where various animals feed.



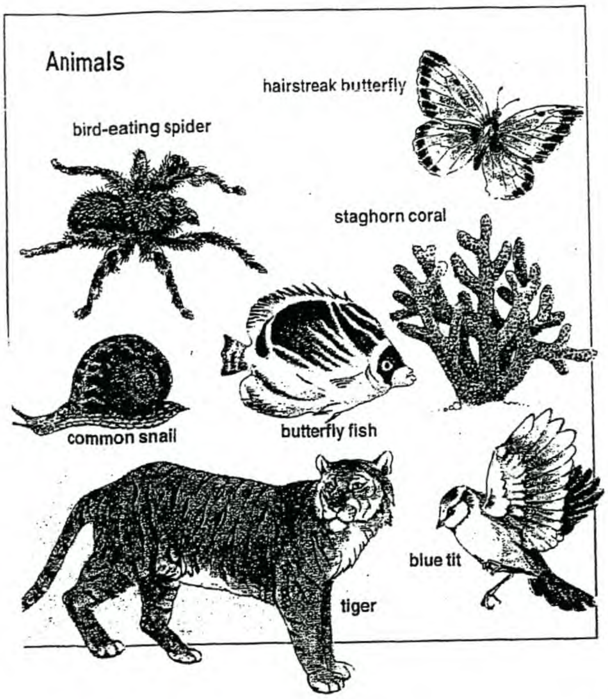
What is each animal in the drawing eating?
Is it a browser or a grazer?
How can all these animals live in one area and yet have enough food?

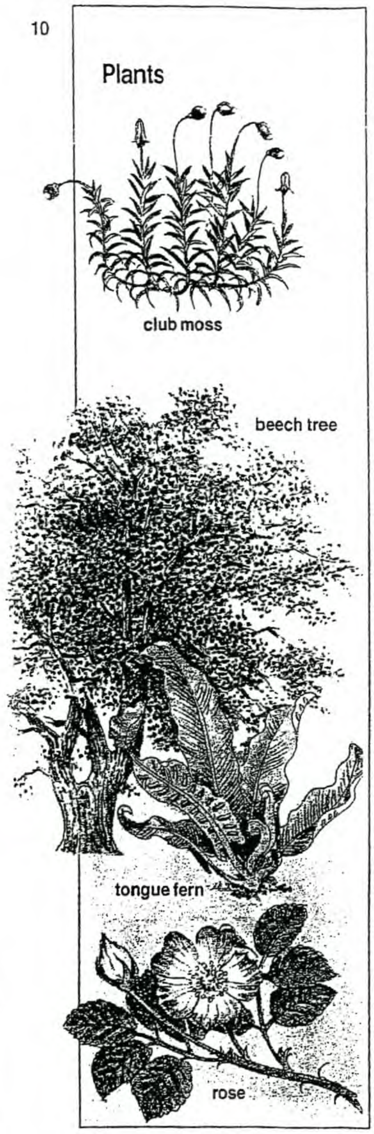
From Cadle, General Science 4

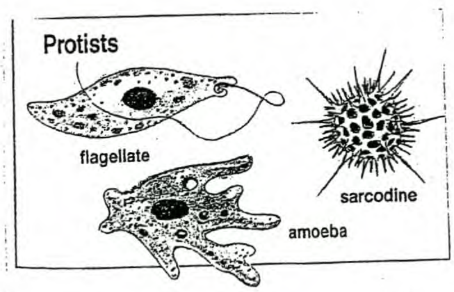
Dividing things into groups

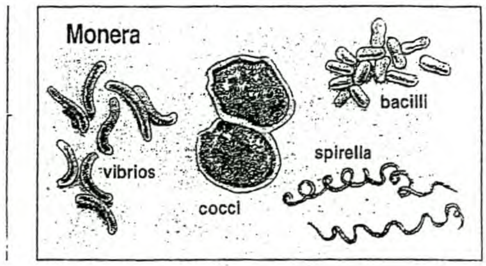
The five kingdoms

10









Summary of the Subject: "Solution"

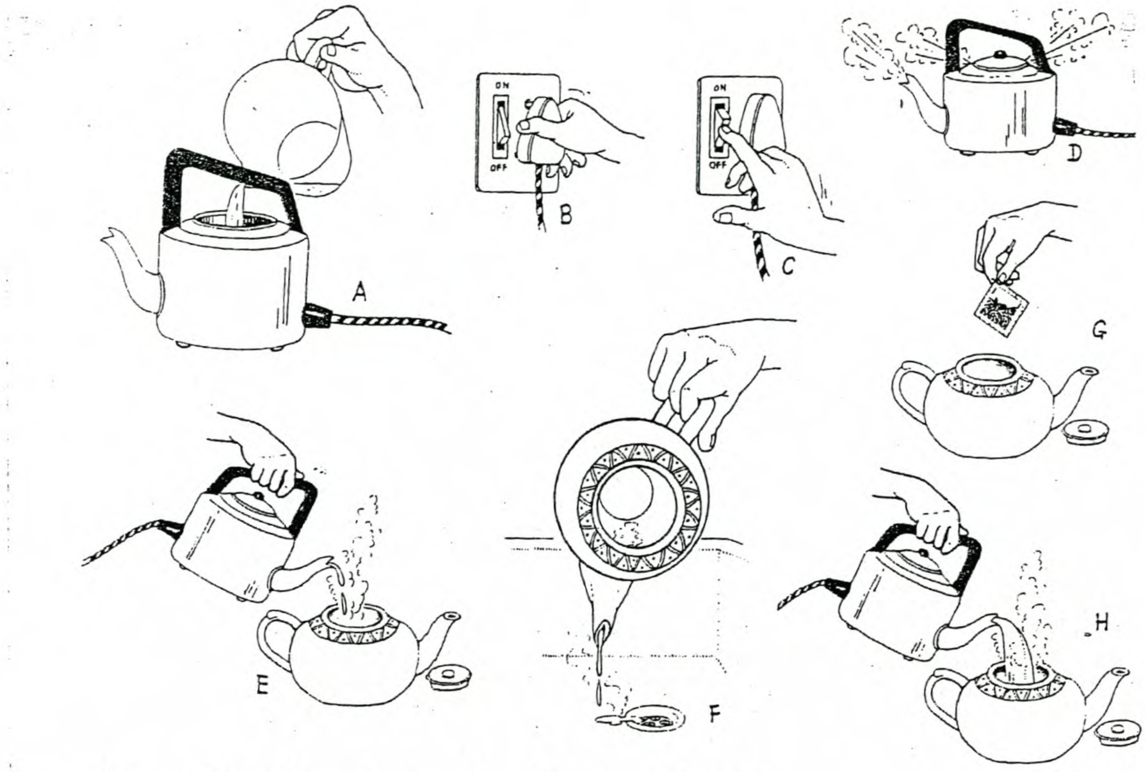
Summary of the Skills: measure, compare observe follow Instruction Collect & Record Data

Find all the words...

Check that you understand the meaning of them!

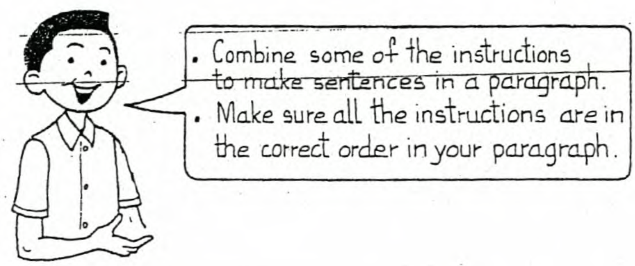
Systematical	Follow	Temp	Km
Approach	Instruction	CHECK	Feet
Measure	SOLUTION	Work	Gr.
compare	Factor	Goal	Kg
collect	Solvent	Define	Experiment
Record	Solubility	Salt	Hot
Observe	Solute	Sugar	
DATA	stir	ml	

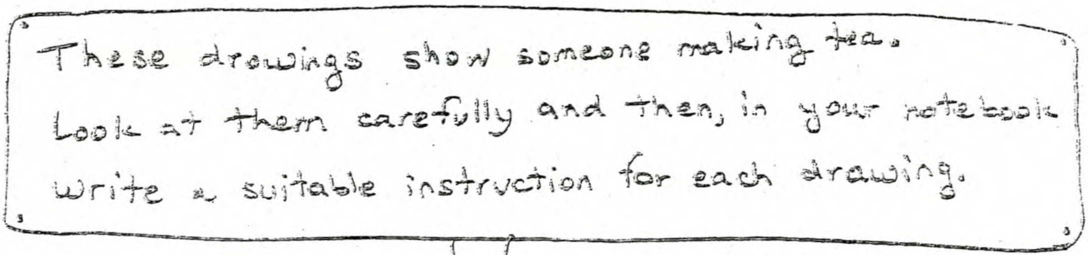
Y	T	I	L	I	B	U	L	O	S	Y	W
F	N	C	O	M	P	A	R	E	U	T	X
O	O	H	S	K	G	S	R	V	T	N	H
L	I	E	Y	V	A	U	G	R	C	E	O
L	T	C	S	L	S	G	R	E	E	V	T
O	C	K	T	A	Y	O	R	S	L	L	N
W	U	F	E	E	T	A	E	B	L	O	E
E	R	M	M	C	U	L	C	O	O	S	M
N	T	L	A	P	P	R	O	A	C	H	I
I	S	F	T	E	M	P	R	K	P	S	R
F	N	R	I	T	S	L	D	R	D	U	E
E	I	V	C	E	T	U	L	O	S	G	P
D	U	D	A	T	A	M	G	W	V	A	X
K	S	O	L	U	T	I	O	N	S	R	E



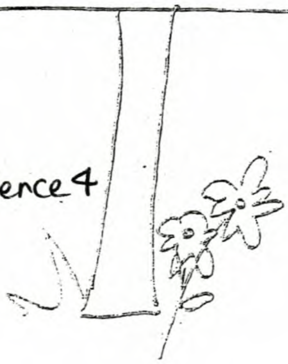
Now write a short paragraph on how to make tea.

Hints:

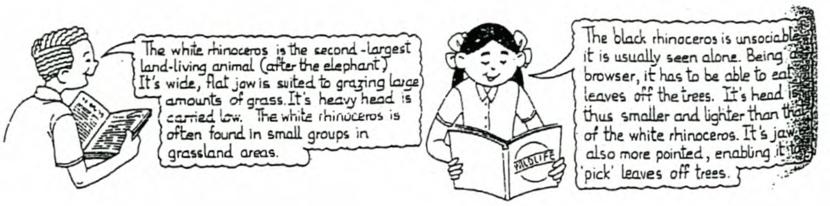




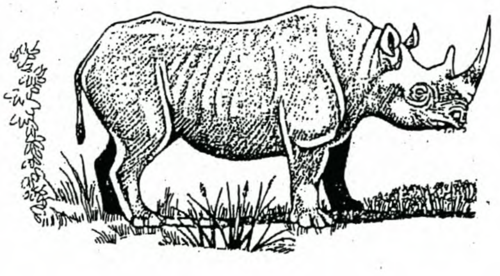
From Cadle, General Science 4



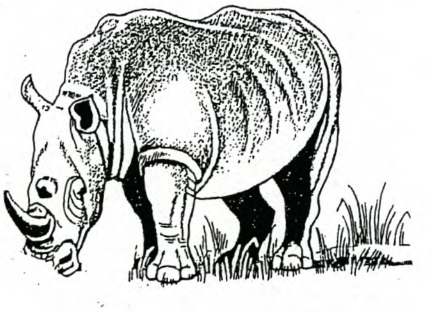
A black rhinoceros and a white rhinoceros have different feeding habits. Read these descriptions of each one, then look at the drawings.
Identify which is which.



A.



B.



Which rhinoceros is a grazer? How is it suited to grazing?
Which rhinoceros is a browser? How is it suited to browsing?

From Cadle,
General Science 4

Day: ____________________

Recorded by: _____________

Feeding Habits Experiment:

A. Find one living animal. Record exactly where you have found it.

Try and classify it into one of the animals group (such as reptiles...). Observe it and describe it behavior for 10 min.

Animal's name: (if you know...)	The place you found it: (For example: on a leave...)	To which group of animals it belongs:	What does it do?

B. Now you have to check out if your animal is a herbivore, a carnivore or an omnivore.

What is your experimental goal? ____________________

What is your strategy? ____________________

What is the factor you are going to change? ____________________

How many times you are going to check it? ____________________

Describe your experiment: ____________________

____

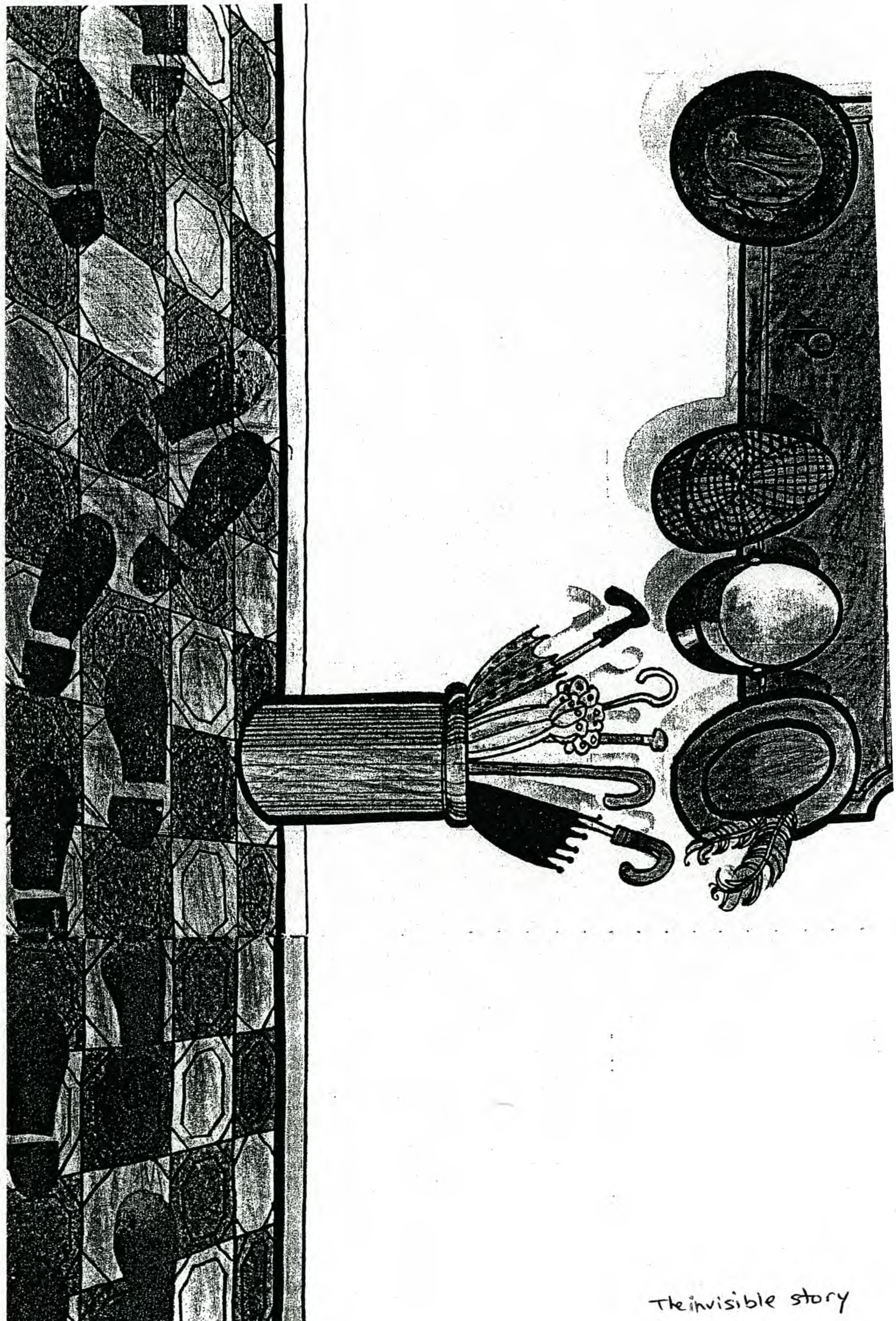
____

What is your conclusion? ____________________

____

Thank you and good luck!

'The invisible Story'



The invisible story

Factors.

A. Read this:

Dina and Yael were studying to their test in science.

Dina was studying hard all day and went to sleep quite early, having a good night sleep.

Yael didn't study enough and went to sleep very late.

Dina succeeded very well in her science test.

Yael didn't succeed so much in her science test.

Q. Can you conclude from this set of facts what is necessary for success or failure in a science test?

B. Read this:

Dina and Yael work in a laboratory. They wanted to check the solubility of salt. (Solubility is how well does solute dissolve in solvent.)

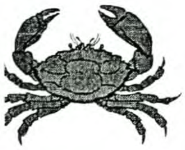
- Dina added 200 ml of hot water to 4 teaspoons of salt and stirred it.
- Yael added 200 ml of tap water to 4 teaspoons of salt and didn't stir it.

Their results were:

- In Dina's cup all salt dissolved.
- In Yael's cup only little salt dissolved.

Together with your group discuss and write your answers to this question:

Q. Can you conclude what affected solubility in both cases? (What factor?)



Fishing for Information... in the Aquarium...

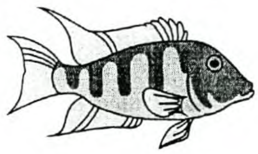
Who am I?

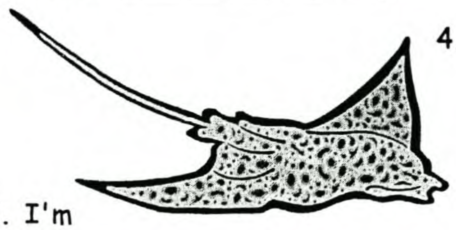
1. You cannot ride  on me because I'm too small...

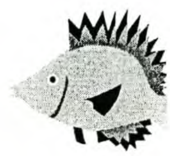
   ____________________.

2. I have 5 limbs and relatives in the sky...

   __________________________.

3. I have a very  long nose and I swim on my head... __________________.





4. I have 8 legs, 2 hands and I look like a cockroach...

   _______________.

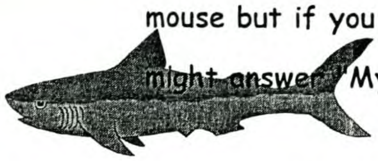
5. I'm round, purplish, with 4 tails...

   ________________________________.

6. We come in different colors, some green, some yellow and some look like a tiger... people think we are snakes... but actually..._____________.

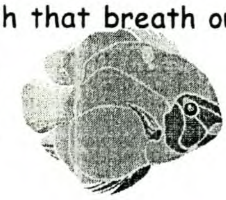
7. We live in deep water, look a  bit like aliens spaceship..._____________.

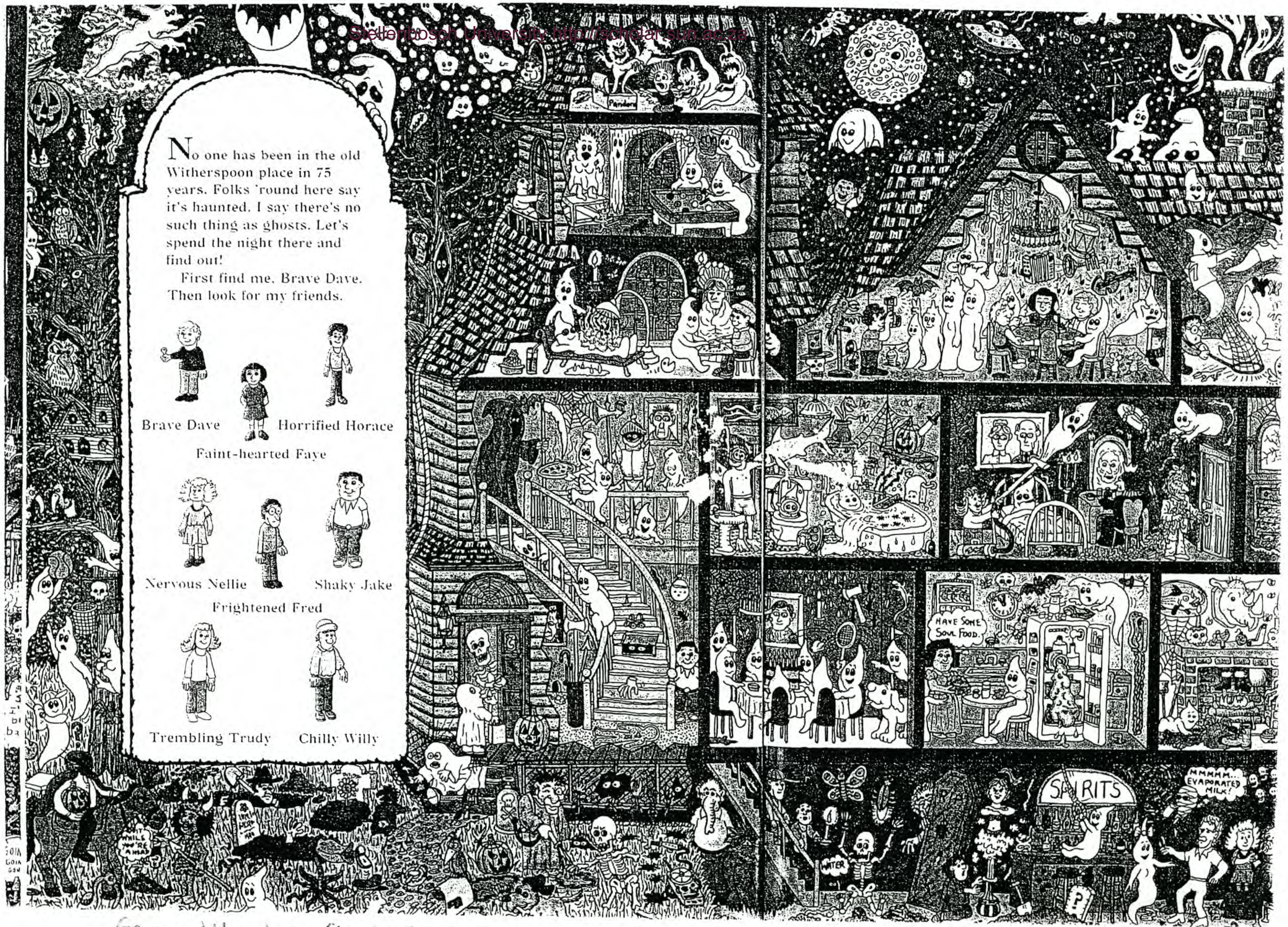
8. We look like big butterfly, we won't catch a mouse but if you ask for our name- we might answer "Myaouu..." ___________________________.



In the living dead area:

9. I am a fish that breath outside water... _________________________.

10. We are  related to horses and we have a



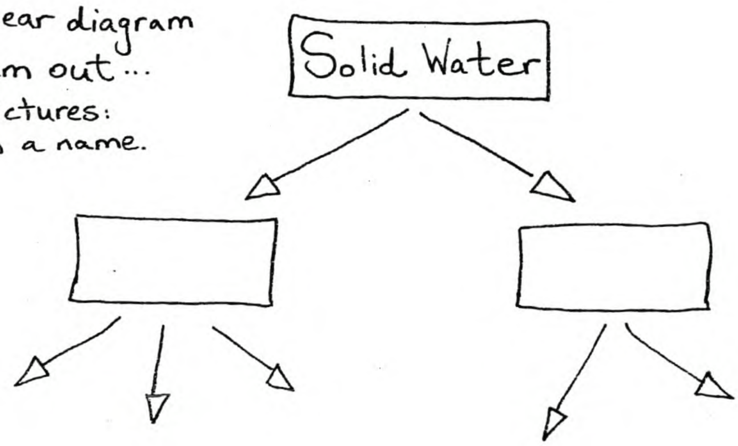
From Witches, Ghosts & Goblins, Temo 1992

Name: ________.

Solid water can be useful. Sometimes it also causes problems. Look at the drawings. Can you sort them into useful and problem-causing groups?

'hat to do?
Use this linear diagram
to sort them out...
Lable the Pictures:
Give them a name.

From Cadle
General Science 2



Please Read, and Classify according to the 3 Phases of water:

Use the linear diagram and: 1. SOLID, 2. LIQUID, 3. GAS

Phases of water in nature

There is **invisible water vapour** in the air.

Clouds form when humid (moist) air rises to places high in the atmosphere where the air is cool. Here the water vapour condenses to form small drops of water which make up the cloud.

When many small drops join to make larger drops, **rain** falls.

Hail is formed in thunder clouds when very cold water in the clouds freezes on small ice crystals. In this way **hailstones** grow in size and fall to the ground. What damage can hail cause?

When the temperature of the air in which a cloud forms is very low, the water vapour can change into **ice crystals** called **snow.**

Mist is formed when water vapour in the air condenses to form tiny drops of water. These drops of water remain in the air as mist. Sometimes mist forms on hills but not in valleys. At other times it forms in valleys and not on hills. What does this tell you about the temperatures of the air on hills and in valleys at different times of the year?

At night as the air cools down, water vapour may condense on cold surfaces to form **dew**. On which surfaces is dew more likely to form? Get up early one morning to find out.

On very cold nights, the water vapour in the atmosphere can change directly into ice crystals which we call **frost**.

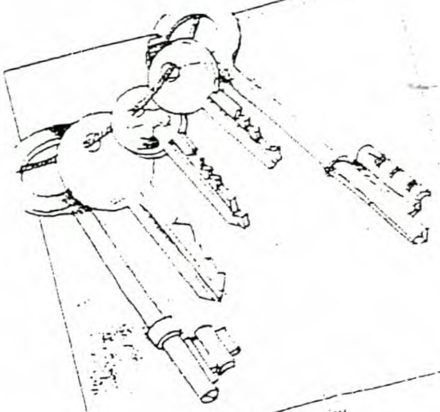
Name: ______

From Cadle
General Science 3

What is the world made of?

The world is made up of all sorts of things. Just look around you. There are houses, cars, trees and people. All these things are different shapes, sizes and colours. Look closely at some of them. They are made from different materials. Some are hard and cold. Others are soft and warm. They may be wet or dry, rough or smooth. All these things look and feel different to us.

All the different things in the world have one thing in common. They are all made of something and they all take up space. Anything which takes up space is called **matter**. So a pencil, a book, a house, a tree, the air and everything around you is matter. You are matter, too. The whole Earth is matter and so are the stars throughout the universe and the dust that drifts between them.



These keys are made of hard, shiny metal. Hardened metal will not change its shape. What other solid objects can you find?

What is matter?

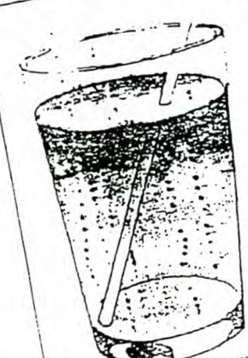
Our world is made of matter. The Earth's crust is **solid**, the sea is **liquid** and the air is a mixture of **gases**. Some matter, such as rocks and wood, are called solids. They don't change their shape. Lemonade and water are called liquids because they flow easily. If you pour a liquid into a container, it flows to fill up the shape of the container. The surface of the liquid is always level. Gases, like the air we breathe, spread to fill any space.

A balloon floats through the air because it is filled with hot gases. Air is a mixture of gases, too.

Our world is made out of... ____ ________.

Matter is anything that... ______________________________

Give 2 examples of Matter... ____________, ____________



You can pour a fizzy drink into a glass. But if you spill any, the liquid drink will spread out in a wet puddle.

Matter can be found in 3 states: <u>Solids</u> <u>Liquids</u> <u>Gases</u>

1 Solids are... ______________________________

1 Liquids are... ______________________________

Gases are... ______________________________

Name..........

Science World: the MTN Center

- Do you remember you measured your weight in one of the lessons?

Can you measure your weight on other planets like...?

On the Moon...  ______________

On Venus... ______________

On Earth... __________

On Pluto... ____________

On Jupiter... ______________

On Mercury... ________________

- Can you put them on a continuum scale? From the lowest number to the highest. Indicate where your weight would be counted the highest...

- Does your weight really change? ____________________________

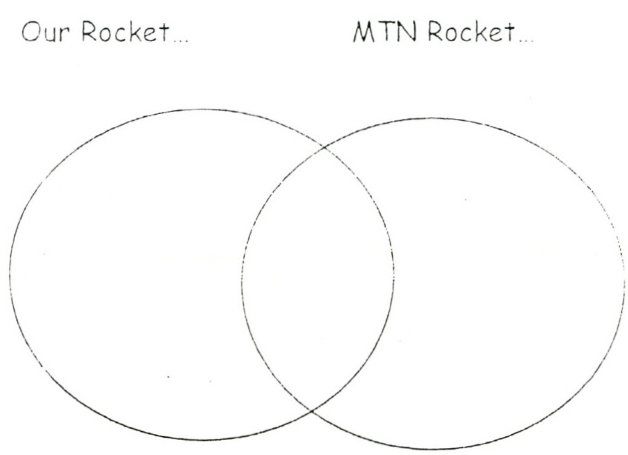
____

- Try the rocket thing ....

In what ways it is similar to our balloon rocket? ______________________

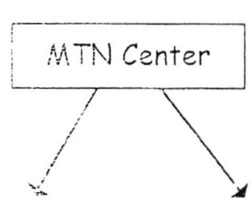
In what ways it is different? ______________________________

Can you compare them using the Venn diagram?



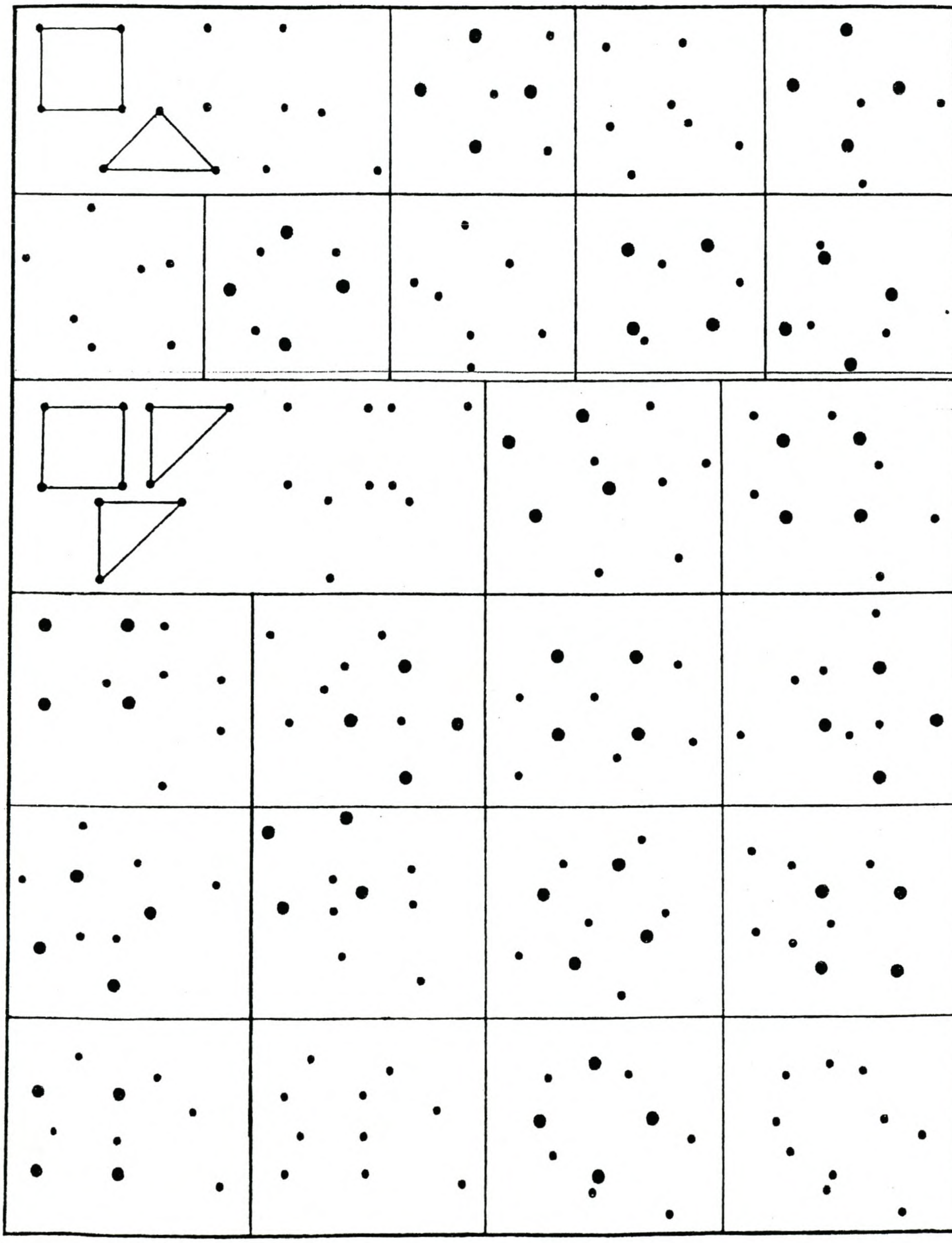
- The activities in this place are divided into different areas.

See if you can build a linear diagram, classifying MTN Center into the different groups... think what is the principle they have used...

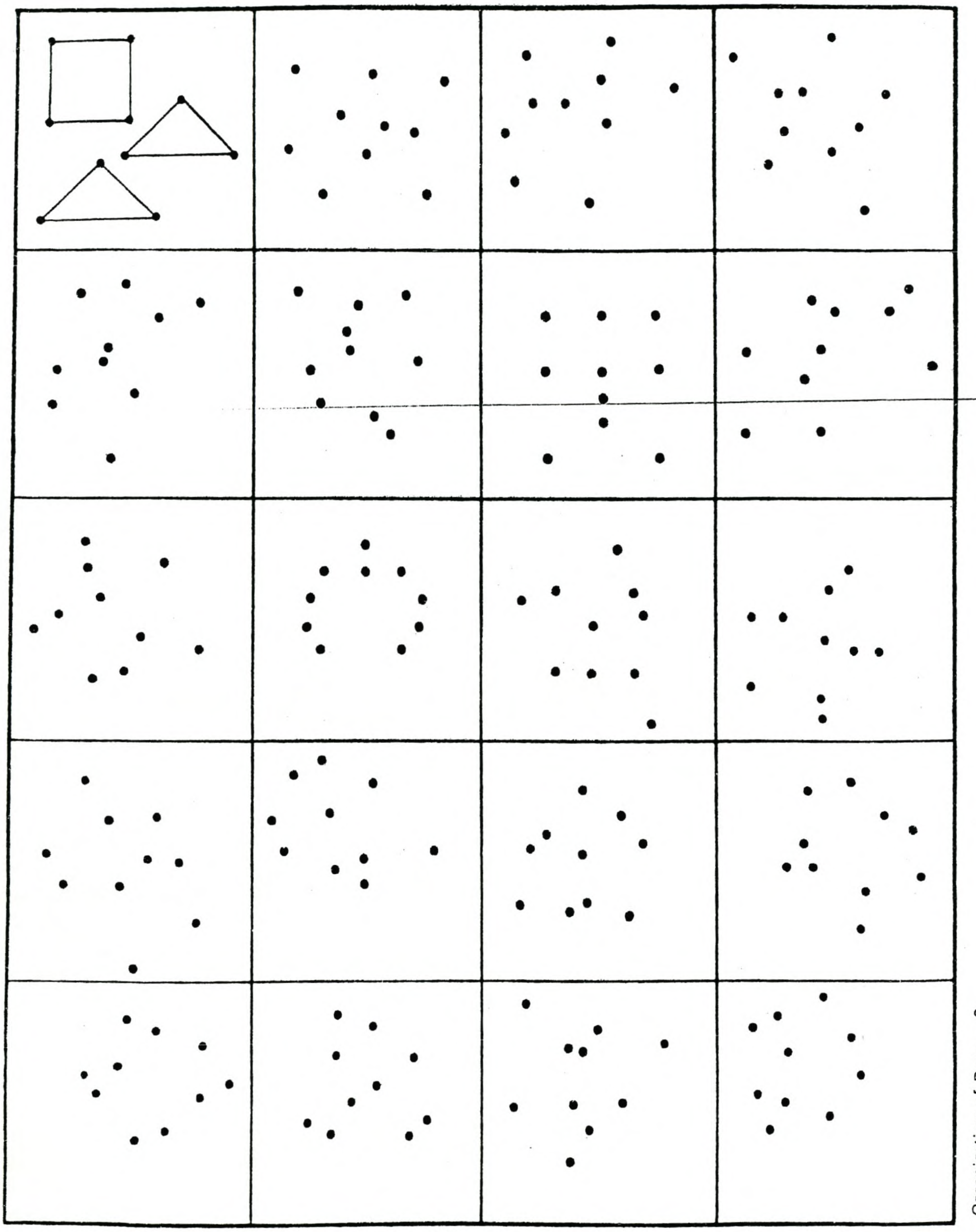


Enjoy your visit....
Nilly

Appendix C



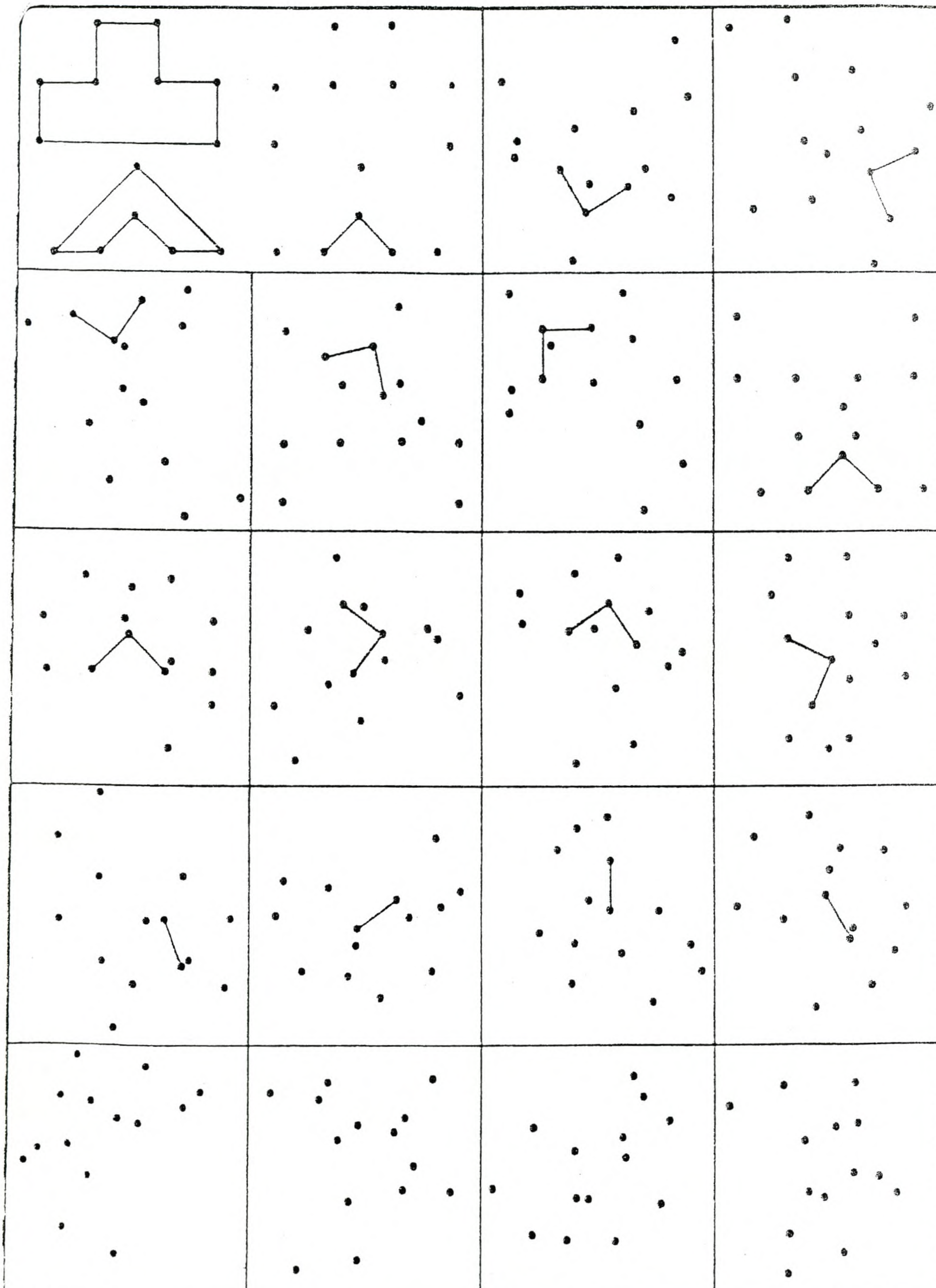
Organization of Dots — 1



Organization of Dots – 2

3

A.V. 2

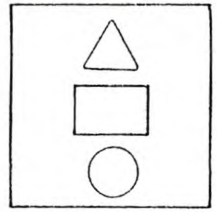


Organization of Dots -- 3

1. The rectangle is in the ______________ of the frame.

What is below the rectangle? ______________.

What is above the rectangle? ______________.



2. In the lower part of the frame there is a ______________ .

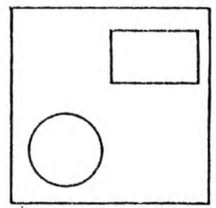
Above the line, draw two squares.

Below the line, draw a rectangle.

3. To the right of the circle, draw a triangle. To the left of the rectangle, draw a square.

What is below the rectangle? ______________.

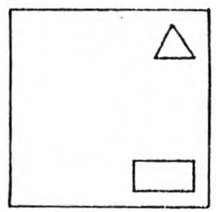
What is above the circle? ______________.



4. In the upper right side of the frame there is a ______________ .

In the lower right side there is a ______________ .

Draw a circle below the triangle, and a square above the rectangle.

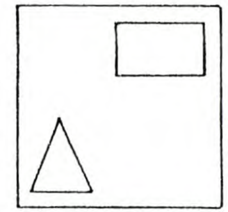


5. Draw two squares so that one is in the upper right and the other is in the upper left of the frame.

Below the square on the left, draw a circle.

6. Draw a square next to the rectangle.

Be sure that the square is not above the triangle.

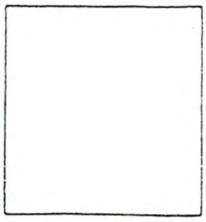
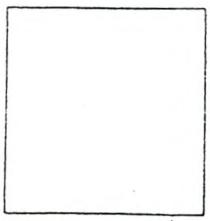
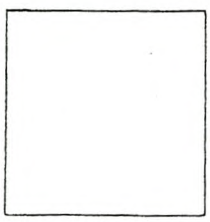
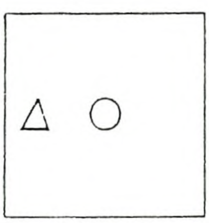
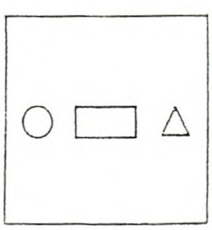


7. In the frame, draw a triangle, a square and a circle.

Draw the square in the lower right side, below the triangle and to the right of the circle.

8. In the frame, draw a circle, a triangle and a square so that the circle appears in the upper right corner, and the square appears below the circle and above the triangle.

The square appears ______________ the circle and the ______________.

	Draw a circle in the center of the frame.
	Draw four small circles in the frame, so that there is one circle in each of the corners.
	Draw a square in the center of the frame. To the right of the square which you have drawn, draw a circle.
	In the __________ of the frame there is a circle. To the __________ of the circle, there is a ________________ .
	The rectangle is in the _____________ of the frame. The triangle is to the _____________ of the rectangle. The circle is to the _________ of the _________ .

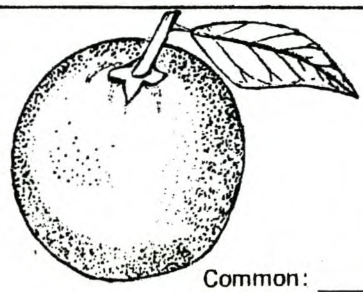
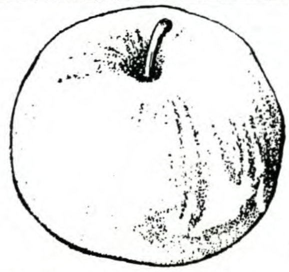
Indicate what is common to each pair of pictures and the differences between them. **1**


Common: ____________

Different: ____________ Different: ____________

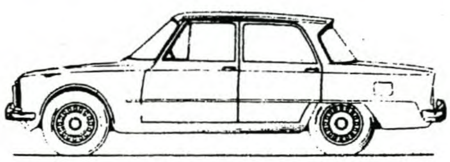
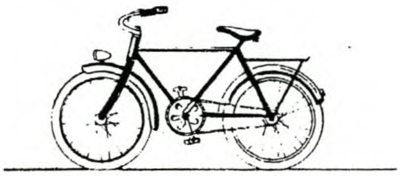

Common: ____________

Different: ____________ Different: ____________

Common: ____________

Different: ____________ Different: ____________

Common: ____________

Different: ____________ Different: ____________

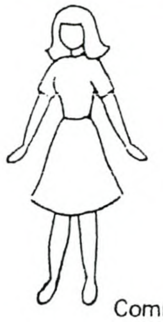

Common: ____________

Different: ____________ Different: ____________

Comparisons – 1

In one word, indicate what is common to both pictures.
Choose one word to describe the difference between them.

5



Common: ____________________

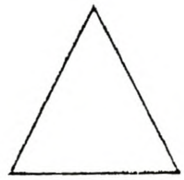
Different: ____________________

6

Common: ____________________

Different: ____________________

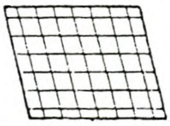
7



Common: ____________________

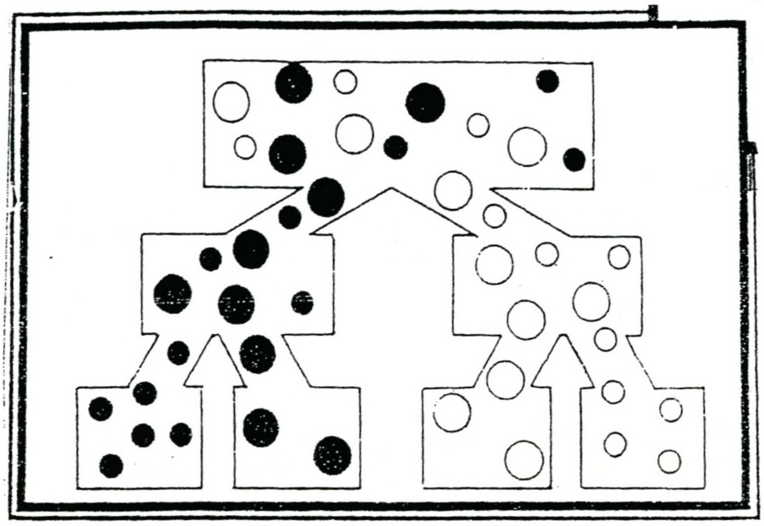
Different: ____________________

8

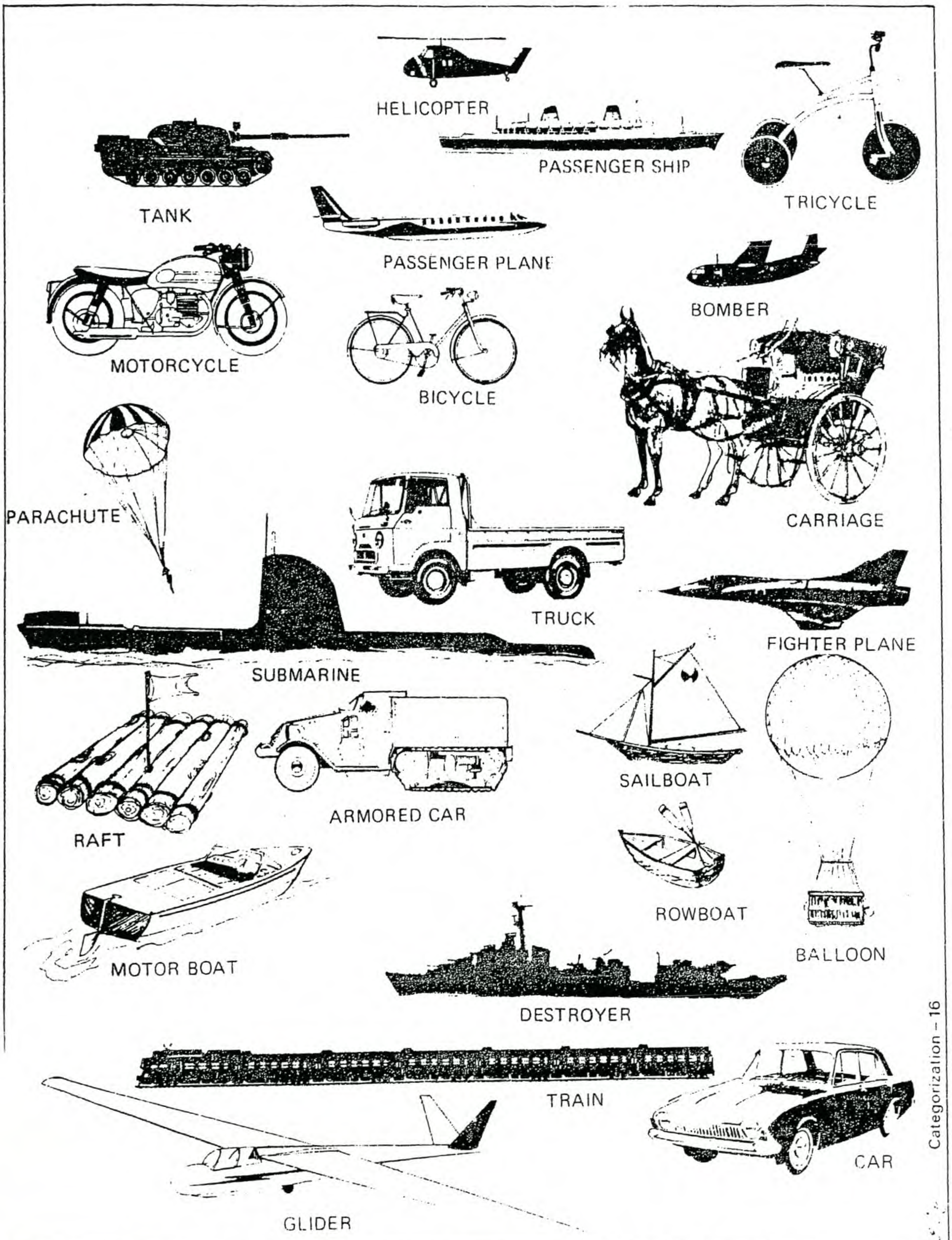


Common: ____________________

Different: ____________________



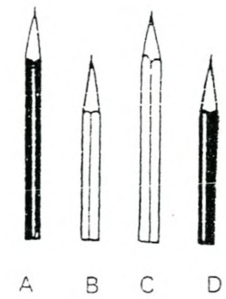
Categorization



Can U sort those into gr...
State which principle U have
" what is the Subject

CLASSIFICATION OF PENCILS ACCORDING TO SIZE AND COLOR 5

1. <u>Classification according to size:</u>



Classify pencils A, B, C, D according to the headings in the table. In each empty square write the appropriate letter.

Subject of classification: PENCILS

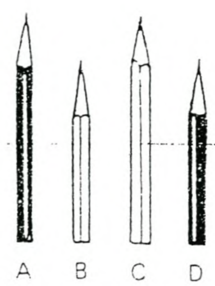
Principle of classification: size: (1) large (2) small

PENCILS

PRINCIPLE OF CLASSIFICATION :
SIZE

SMALL	LARGE

2. <u>Classification according to color:</u>



Classify the same pencils A, B, C, D according to the headings in the table. In each empty square write the appropriate letter.

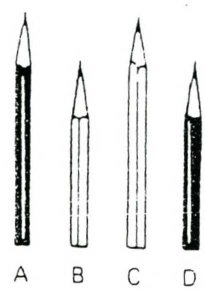
Subject of classification: PENCILS

Principle of classification: color: (1) white (2) black

PENCILS

PRINCIPLE OF CLASSIFICATION :
COLOR

BLACK	WHITE

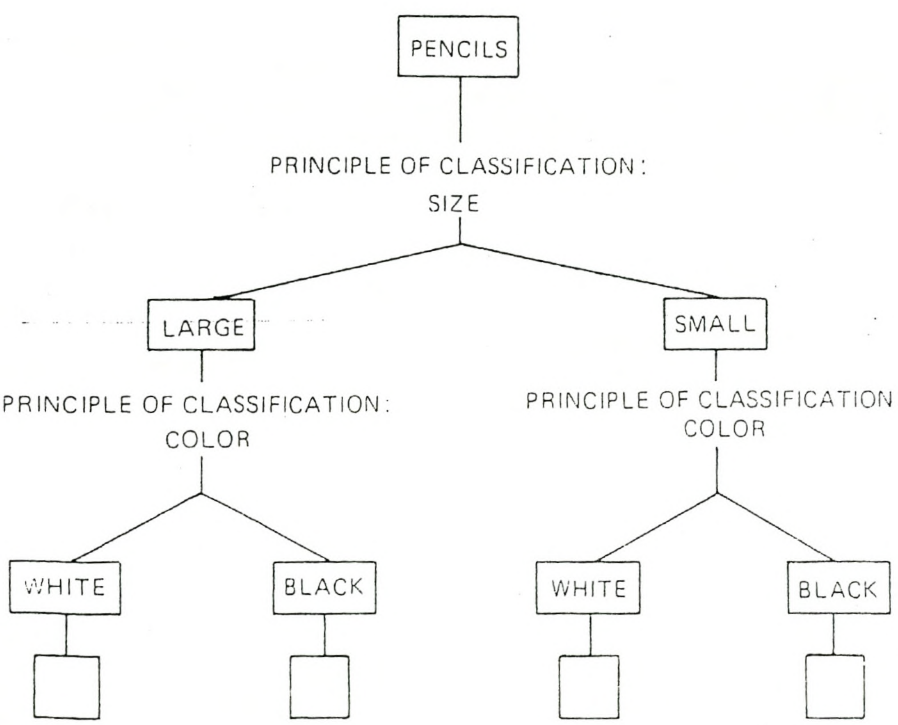


3. Classification according to size and color:

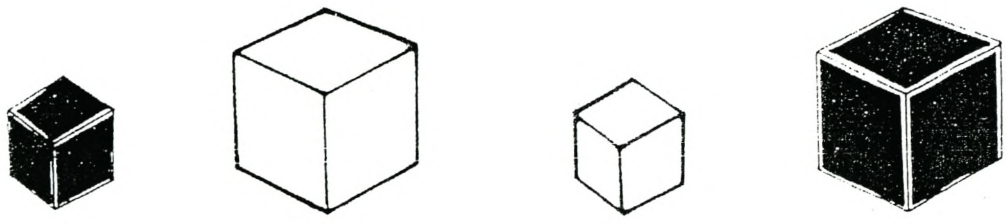
Classify the same pencils A, B, C, D according to the headings in the table. In each empty square write the correct letter.

Subject of classification: PENCILS

Principles of classification: size: (1) large (2) small
color: (1) white (2) black



CLASSIFICATION OF CUBES ACCORDING TO SIZE AND COLOR



A B C D

Here are four cubes marked A, B, C, D.

1. Fill in what is missing.

White cubes: ________ , ________

Black cubes: ________ , ________

Large cubes: ________ , ________

Small cubes: ________ , ________

Cube A is <u>black and small.</u>

Cube B is ______________________________ .

Cube C is ______________________________ .

Cube D is ______________________________ .

2. Which cube is small and white? __________

Which cube is black and large? __________

What do cubes B and D have in common? ______________________________

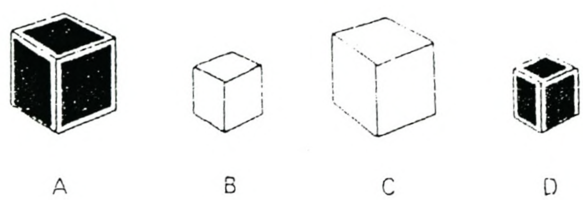
What do cubes A and D have in common? ______________________________

Which two cubes are dissimilar both in color and size?

__________ , __________

__________ , __________

3. Write the correct letter in each empty square.

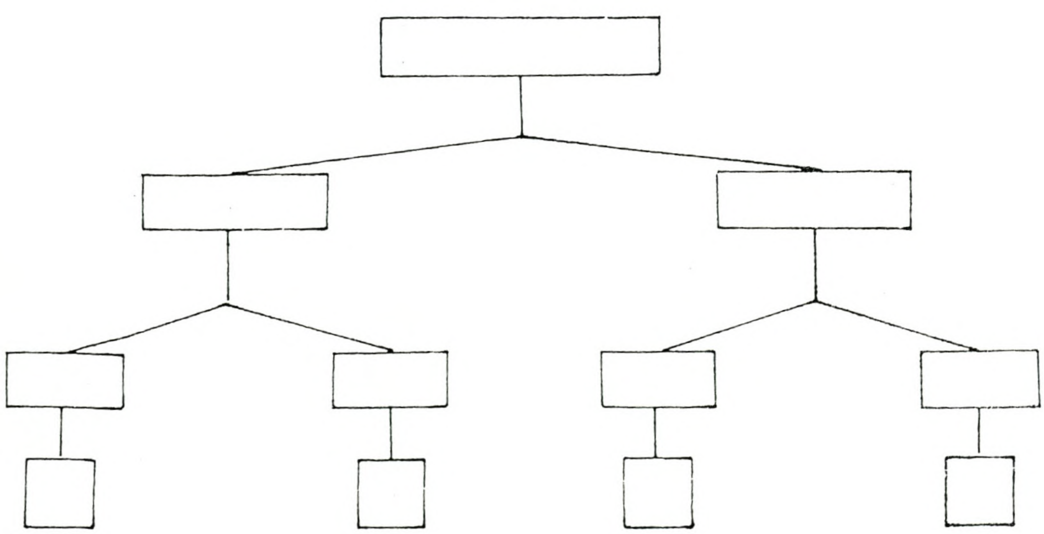


		SIZE	
		SMALL	LARGE
COLOR	WHITE		
	BLACK		

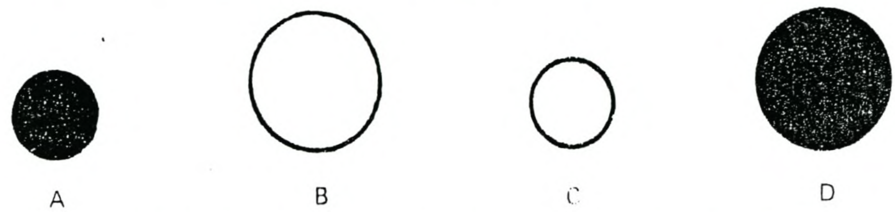
4. Classify the cubes according to size and color. Fill in the headings and write the correct letter in each empty square.

Subject of classification: ______________________________

Principles of classification: ______________________ : (1) ______________
(2) ______________
______________________ : (1) ______________
(2) ______________



CLASSIFICATION OF CIRCLES ACCORDING TO SIZE AND COLOR

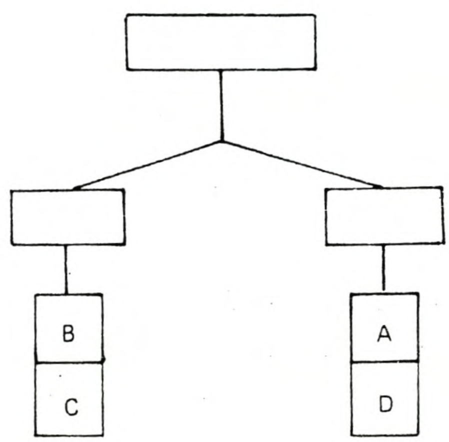


Here are four circles marked A, B, C, D. Write the headings so that the letters in the squares will be correct.

Subject of classification: ______________________

Principle of classification: ______________________

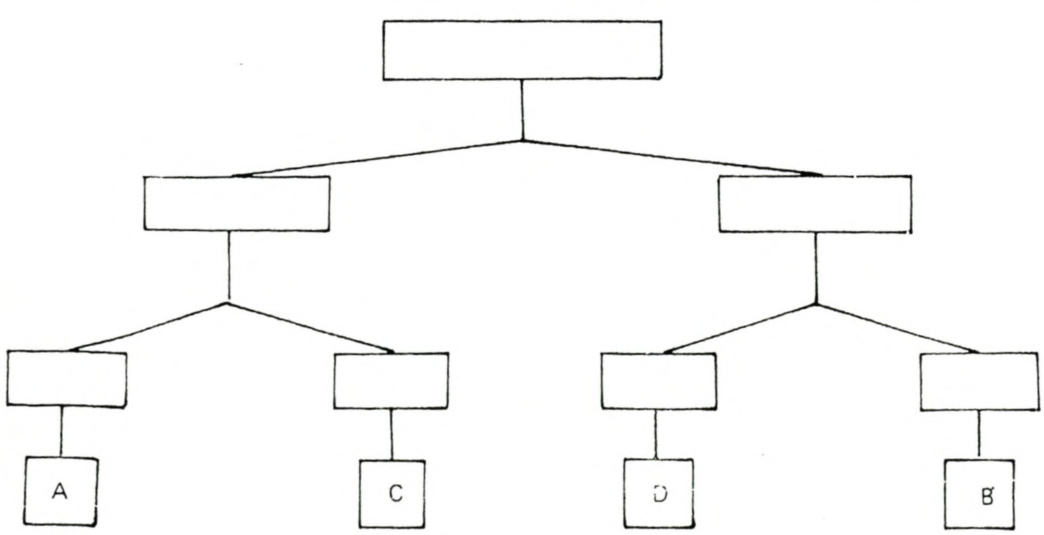
(1) ________________ (2) ________________



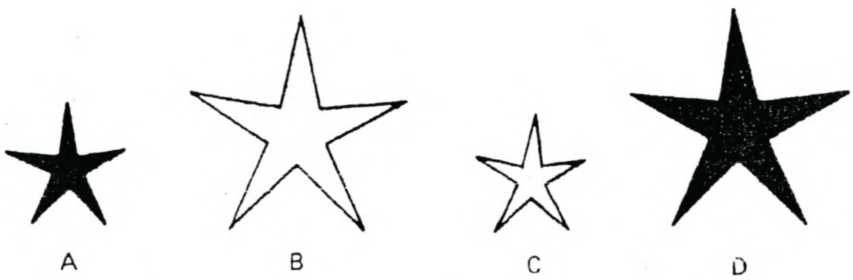
Subject of classification: ______________________

Principles of classification: ______________________ : (1) ____________ (2) ____________

______________________ : (1) ____________ (2) ____________



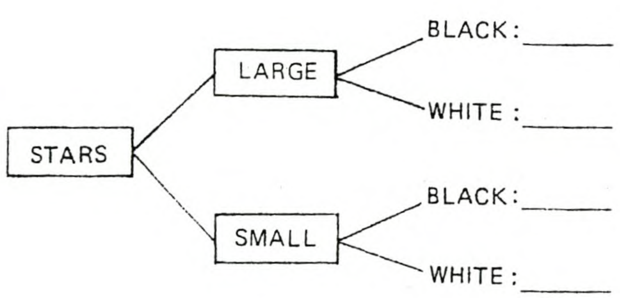
CLASSIFICATION OF STARS ACCORDING TO SIZE AND COLOR **10**



Here are four stars marked A, B, C, D. Classify them according to size an I color and write the correct letter on the appropriate line.

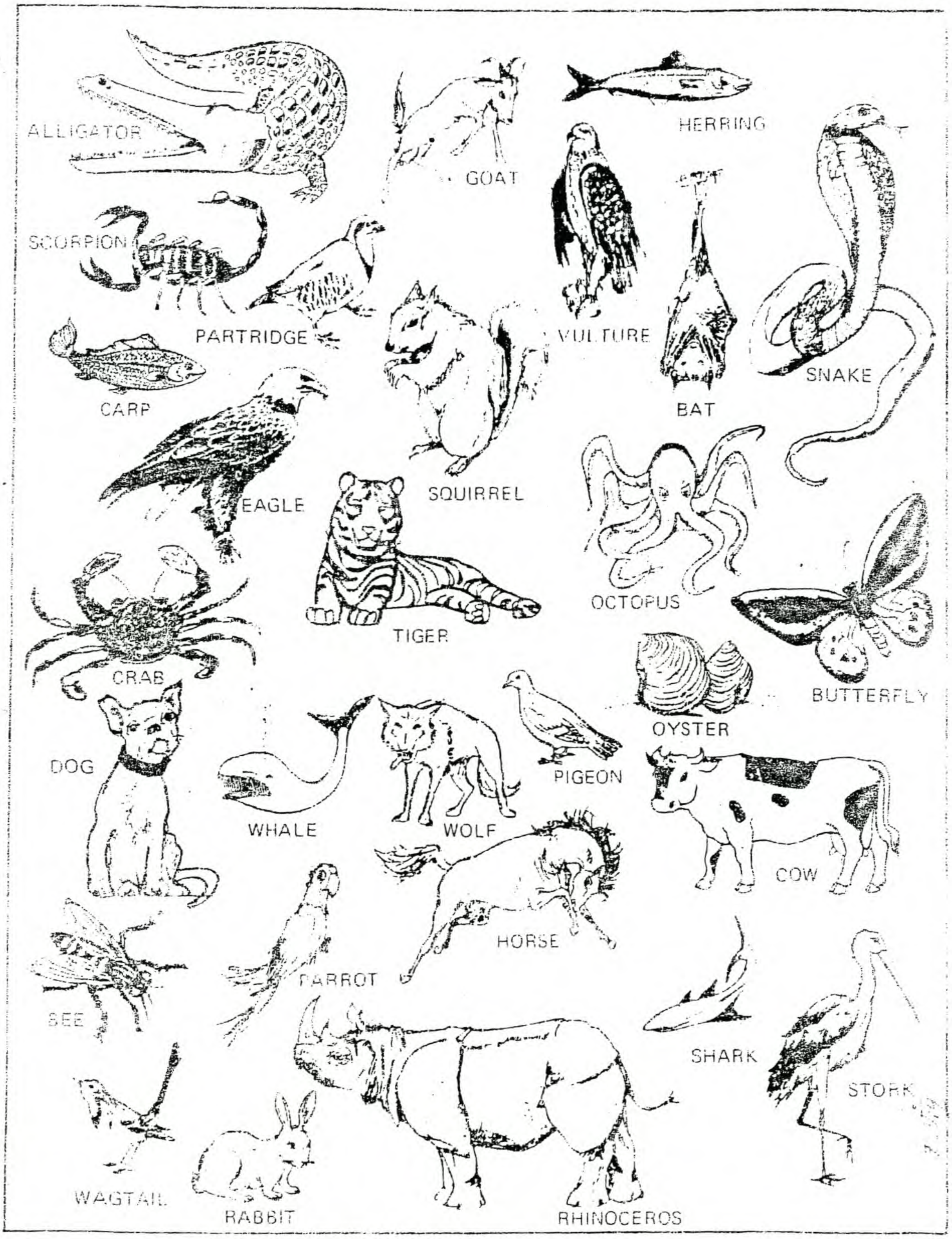
Subject of classification: STARS

Principles of classification: size: (1) large (2) small
color: (1) black (2) white



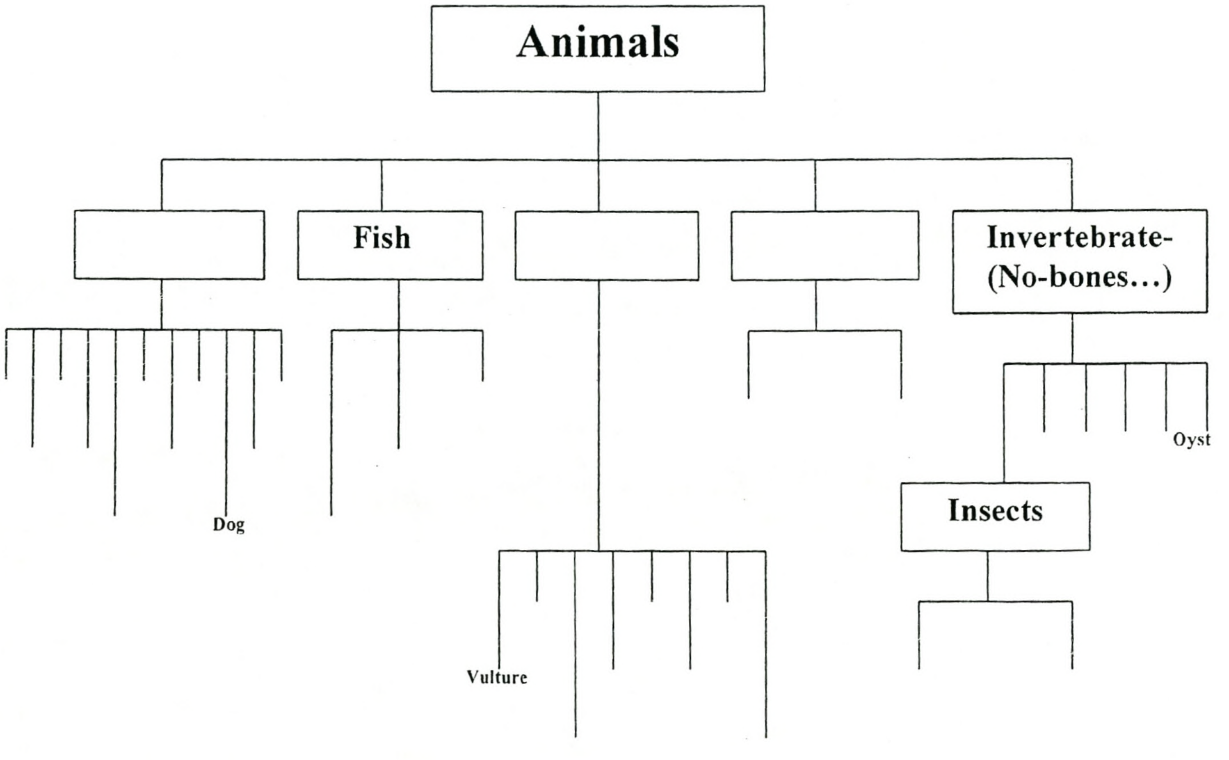
Put a circle around the words that describe the color and size of each star:

	COLOR	SIZE
Star A	black/white	large/small
Star B	black/white	large/small
Star C	black/white	large/small
Star D	black/white	large/small


ALLIGATOR
GOAT
HERRING
SCORPION
PARTRIDGE
VULTURE
BAT
SNAKE
CARP
SQUIRREL
EAGLE
OCTOPUS
TIGER
CRAB
BUTTERFLY
OYSTER
DOG
PIGEON
WHALE
WOLF
COW
HORSE
PARROT
BEE
SHARK
STORK
WAGTAIL
RABBIT
RHINOCEROS

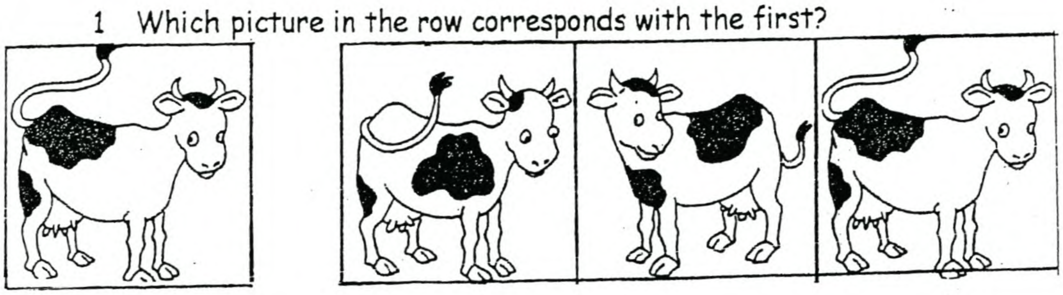
Classification:

- Work with the pictures and classify all animals into groups…
- Make sure you write the title for every group.

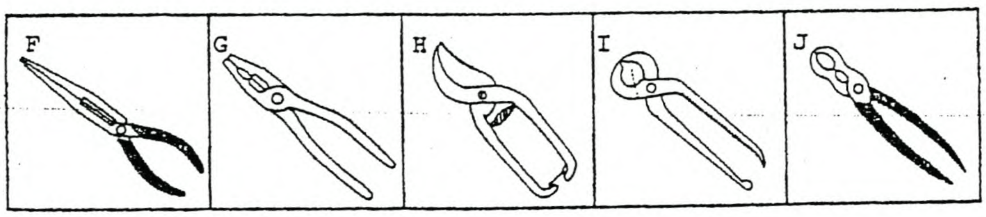


The difference between **classification** - or categorisation - and **comparison** is best illustrated in the following examples:

1 Which picture in the row corresponds with the first?



2 Which item does not belong?



Is it possible to do #2 without using the skills needed for #1? ______
What is the difference between these two questions?

____

____

____

When you classify, you follow these two steps:

1 ____

2 ____

It is not always easy to identify the differences and similarities. When you classify it is important to move from the concrete to the abstract and to recognise the *principle* on which the division is based.

Appendix D

Name: ____________

Grade: ____________

Questionnaire

These last two lessons were about **Systematical Approach to Solve a Task**.

Please indicate how strongly you agree or disagree with each of the statements.

Use the following scale:

(Tick in the proper box)

1	2	3	4	5
Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree

	1	2	3	4	5
12. A plan is a useful tool to solve any task					
13. In order to solve a task I first define the problem.					
14. I never check my work by myself.					
15. I change my plan when it is not helping me to solve my problem.					
16. Usually, I start working and only then I define the problem.					
17. I have no strategy to how to solve a problem.					
18. I decided what steps I was going to take in order to reach my goal.					
19. I don't care about the rules when I solve a problem.					
20. I can't solve a problem by myself.					
21. I use my plan while I am working.					
22. I try and gather information before I solve the problem					

23. I have used the six steps of systematical approach to solve a task when the problem was: (please describe your usage of this approach)____________________________

____

____

____

24. What was the most difficult thing we learnt? ______________________________

____

____.

25. What was the most interesting thing we learnt? ____________________________

____

____.

26. Please remark any other comment on the other side of the page.

Thank You Very much for your Cooperation!

Name: ____________

Grade: ____________

Questionnaire

The **content** of this lesson was **Solutions**.

The main **skill** we learnt today was **Following Instructions**.

Please indicate how strongly you agree or disagree with each of the statements.

Use the following scale:

(Tick in the proper box)

1	2	3	4	5
Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree

	1	2	3	4	5
1. I understand the lesson's content.					
2. I will be able to use the skill we learnt in other classes.					
3. The lesson's content was <u>not</u> clear.					
4. I think I know how to use the skill in science.					
5. When I follow instructions, I read the first sentence, do it and then continue.					
6. I believe it will be difficult to use the skill outside school.					
7. The skill we learnt is difficult to use.					
8. I think the content was difficult.					
9. First, I read the instructions and then I follow it step by step.					
10. The skill we learnt made me think different than I'm used too.					

11. I have used the six steps of systematical approach to solve a task when the problem was: (please describe your usage of this approach)____________________________

____

____

____.

12. What was the most difficult thing we learnt? ______________________________

____

____.

13. What was the most interesting thing we learnt? ____________________________

____

____.

14. Please remark any other comment on the other side of the page.

Thank You Very Much for Your Cooperation!

Name: ____________

Grade: ____________

Questionnaire

The **topic** of this lesson was **Factors**.

Please indicate how strongly you agree or disagree with each of the statements.

Use the following scale:

(Tick in the proper box)

1	2	3	4	5
Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree

	1	2	3	4	5
1. Different factors may influence in the same way.					
2. I will be able to identify factors in different experiments.					
3. When I compare, I look only for differences.					
4. I think I know how to use factors in science.					
5. When I compare, I look for what is the same and what is different.					
6. Table is the only way I know to organize information from a comparison.					
7. Planning an experiment is very difficult to me.					
8. It was difficult to compare using a Venn diagram.					
9. I think I know how to plan an experiment by now.					
10. When I use any factor I use only one at a time.					
11. It was very hard to find factors in the experiment we have done.					

12. Please give one example to situation where you compared something outside school:

____

13. ____

14. ____

15. ____

16. What was the most difficult thing we learnt? ____________________

____

17. What was the most interesting thing we learnt? ____________________

____.

18. Please remark any other comment on the other side of the page.

Thank You Very Much for Your Co-operation!

Name: ____________

Grade: ____________

Questionnaire

The **topic** of this lesson was **Solutions**.

The main **skill** we learnt today was **comparisons**.

Please indicate how strongly you agree or disagree with each of the statements.

Use the following scale:

(Tick in the proper box)

1	2	3	4	5
Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree

	1	2	3	4	5
1. I understand what is a Solute					
2. I will be able to use comparisons in other classes.					
3. I did not understand the topic: Solutions					
4. I think I know how to use comparisons in science.					
5. When I compare, I look for what is the same and what is different.					
6. I believe it will be difficult to use comparisons outside school.					
7. It was difficult to compare objects.					
8. I think the subject 'Solutions' is difficult to understand.					
9. I automatically make comparisons when I work.					
10. Never make comparisons by my self.					
11. It is very hard to compare solutions.					

12. Please give one example to: A Solution: ______________________________

13. A Solute: ______________________________

14. A Solvent: ______________________________

15. What was the most difficult thing we learnt? ______________________________

____

____.

16. What was the most interesting thing we learnt? ______________________________

____

____.

17. Please remark any other comment on the other side of the page.

Thank You Very Much for Your Cooperation!

Name: ____________

Grade: ____________

Questionnaire

The **topic** of this lesson was **Classification**.

Please indicate how strongly you agree or disagree with each of the statements.

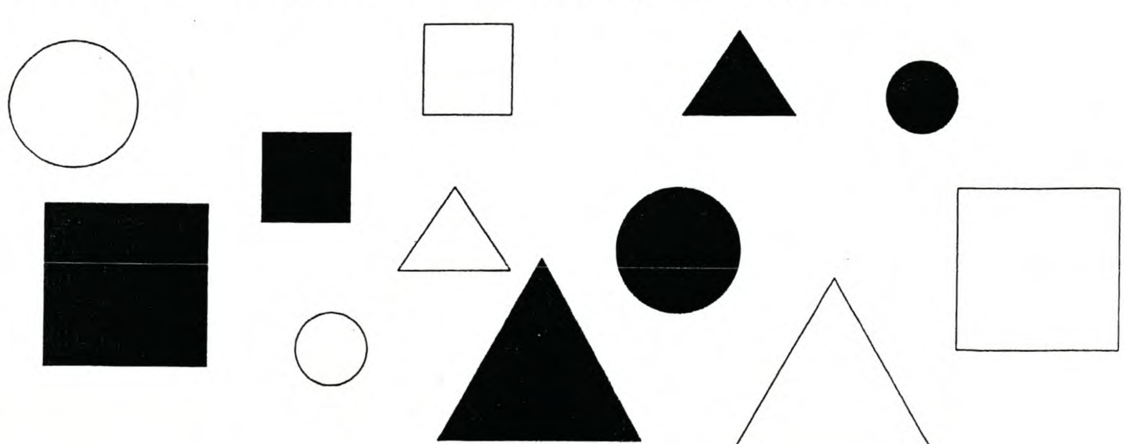
Use the following scale:

(Tick in the proper box)

1	2	3	4	5
Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree

Statement	1	2	3	4	5
1. It is possible to classify all living things into 5 kingdoms.					
2. I will be able to classify animals according to their group.					
3. When I classify, I group things according to one characteristic.					
4. I think I know how to classify things.					
5. A tree and a tiger belong to the same kingdom.					
6. No one can classify outside the classroom.					
7. Animals produce their own food.					
8. All organisms produce their own food.					
9. It was very difficult to classify using the pictures.					
10. Plants produce their own food.					

11. Please **Classify** the geometric forms according to **Size**, **Form** and **Color**



Name: ____________

Grade: ____________

Questionnaire

The **topic** of this lesson was **Organisms and Inferring**.

Please indicate how strongly you agree or disagree with each of the statements.

Use the following scale:

(Tick in the proper box)

1	2	3	4	5
Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree

	1	2	3	4	5
27. To be an organism means to have one sign of life.					
28. I will be able to identify organisms when I'll see them.					
29. When I infer, I look for clues that help me gain meaning.					
30. I think I know what are the signs of life.					
31. Infer means to gain meaning indirectly.					
32. No one can infer outside the classroom.					
33. Cars are organisms because they have a few signs of life.					
34. It was difficult to know what is an organism.					
35. I think I know how to check if something is an organism.					
36. It is very hard to find signs of life left by organisms.					

37. Please give 2 signs of life:

____

12. Can you explain why a car is not an organism?

____

____

13. What was the most difficult thing we learnt? ____________________

____

14. What was the most interesting thing we learnt? ____________________

____.

15. Please remark any other comment on the other side of the page.

Thank You Very Much for Your Co-operation!

Name: ____________

Grade: ____________

Questionnaire

Revision of all skills and some knowledge.

Please indicate how strongly you agree or disagree with each of the statements.

Use the following scale:

(Tick in the proper box)

1	2	3	4	5
Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree

	1	2	3	4	5
1. When I compare, I look for what is the same and what is different.					
2. In order to solve a task I first define the problem.					
3. To be an organism means to have only one sign of life.					
4. I can classify animals according to their feeding habits.					
5. When I classify, I group things according to one characteristic.					
6. When I compare, I look only for differences.					
7. When I use any factor I use only one at a time.					
8. A flower and a lion belong to the same kingdom.					
9. I understand what is a solute.					
10. Animals produce their own food.					
11. Plants produce their own food.					

12. What are the different signs of life? Write down as many as you can…

____

____

13. Please write down one name of a solute: ______________________

one name of a solvent: ______________________

14. Can you explain why a washing machine is not an organism?

____

____

15. Give three examples for kingdoms of organisms: ____________________

____

Thank you...

Name: __________

Grade: __________

<u>**This is part of planning an experiment.**</u>

The goal is to: ***Make the orange trees give less sweet fruits.***

After you gathered information from...

____

____

____,

You came up with 2 strategies. Please write them down:

(1) If I... ____ then...

____.

(2) If I... ____ then...

____.

Please explain 2 rules that will guide your work...

(1) ____.

(2) ____.

Thank You!

Name: ____________

Planning an Experiment...

A farmer came to your laboratory and asked you to help him produce Red Bananas...

1) Define your **goal**:____

____

2) Where you gather your information from?___________________________

____

3) Please write down **2 strategies**: (a) If I...____________________________

_______________Then...____

(b) If I...____

Then...____

4) Please indicate **2 rules** and explain their importance:

(a) _____________________________ it is important because: __________

____

(b)_____________________________ it is important because: __________

____

5) How will you **check** your work? ______________________________________

____

____

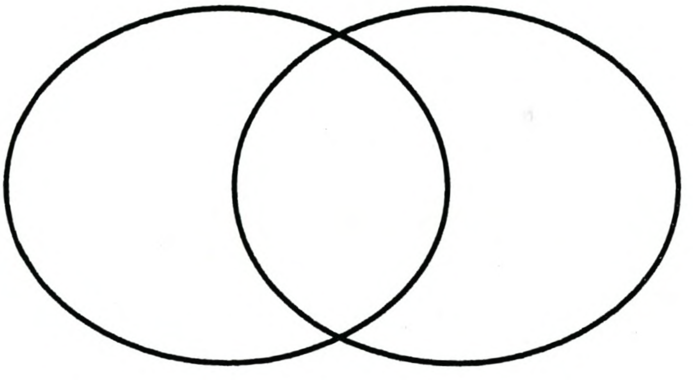
Think Well!

Name: ______________

Factors and Solubility

1. Look at the details of this table and organize the data in a Venn diagram.

The experiment	Cup A	Cup B	Same	Different
Container:	glass	glass	√	
Amount of water	200 ml	200 ml	√	
Amount of sugar	5 teaspoons	5 teaspoons	√	
Temp. of water	25 °C.	25 °C.	√	
Stirring	All the time	Not at all		√



2. What are the factors in this table that can affect solubility?

____

____

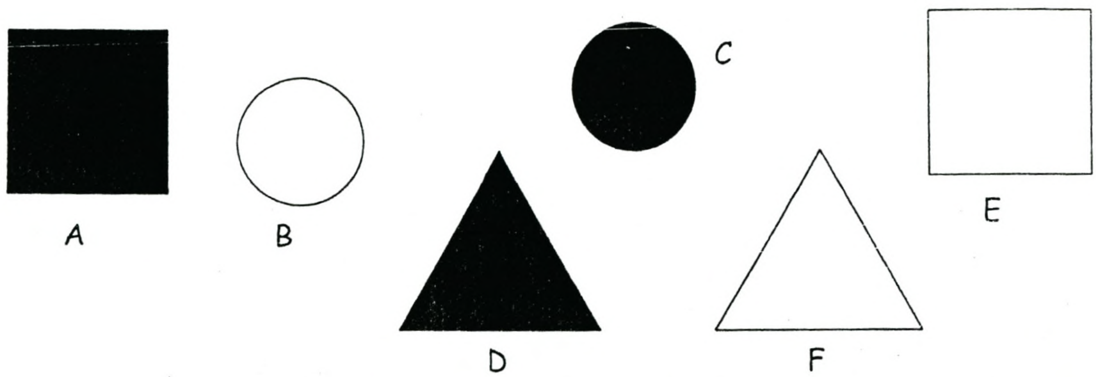
____.

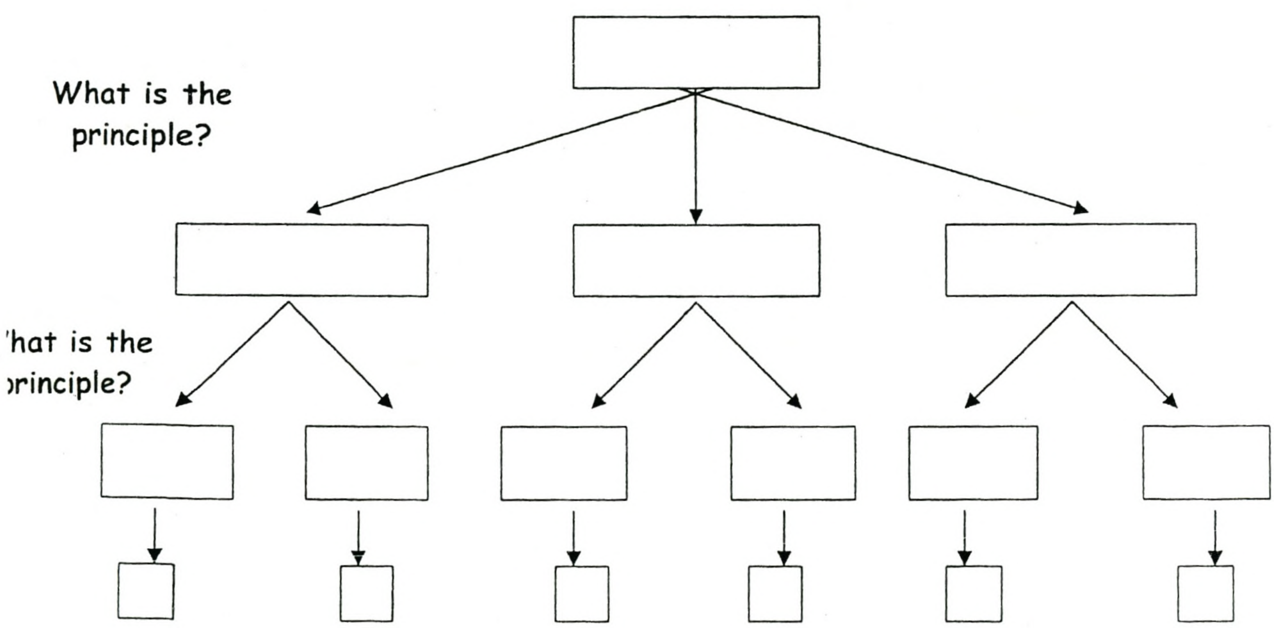
Thank you!

Name: ______________

Please **Classify** these geometric shapes according to

Shape and **Color** using the Linear Diagram:





Name:

Last Quiz!

1. After you came back from the aquarium, you discovered that one fish got into your pocket (!). You want to feed it but you are not sure what food to give it…

Plan an experiment to check what is its favorite food…

Your goal: ______________________________

Gather information… ______________________________

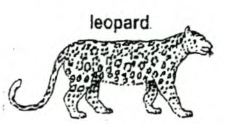
Your strategy: ______________________________

The rules you need to use: ______________________________

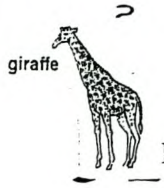
Check your work: ______________________________

What is the factor you changed? ______________________________

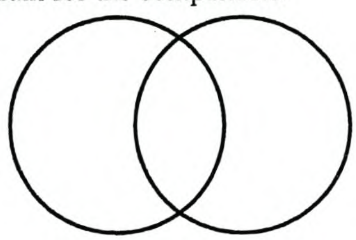
2. Compare the two figures. Use a Venn diagram for the comparison:



A



B



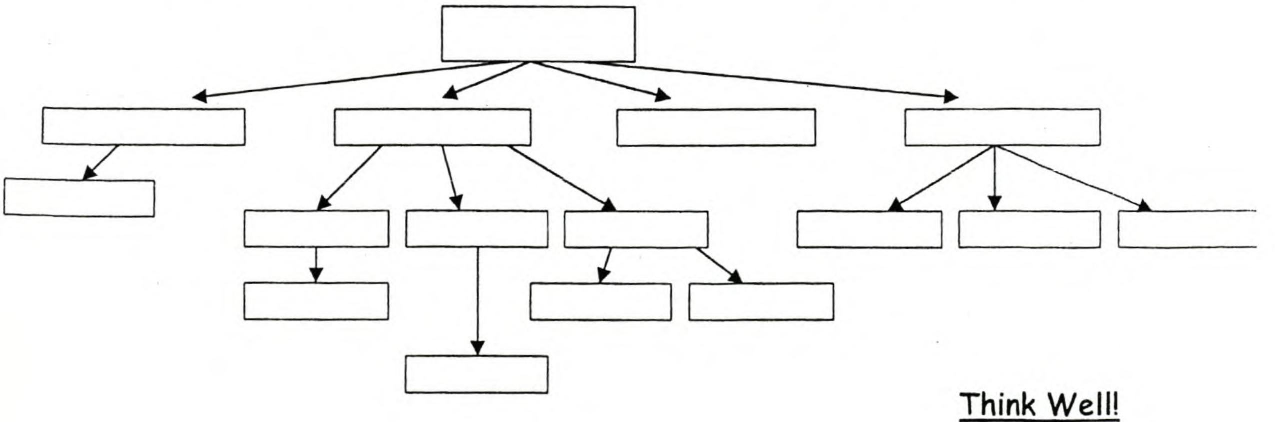
3. Describe 2 ways to make very concentrated solution: ______________________________

____

____

4. Classify these organisms according to the principles we have used.

Organisms, fungi, trees, animals, herbivores, omnivores, snake, bacteria, mushroom, flowers, plants, carnivores, humans, bushes, tiger, butterfly.



Think Well!

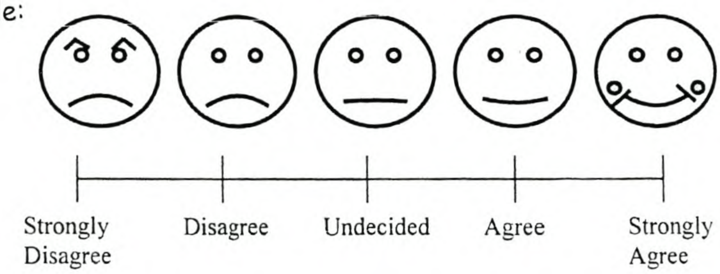
Appendix E

Name: _______________

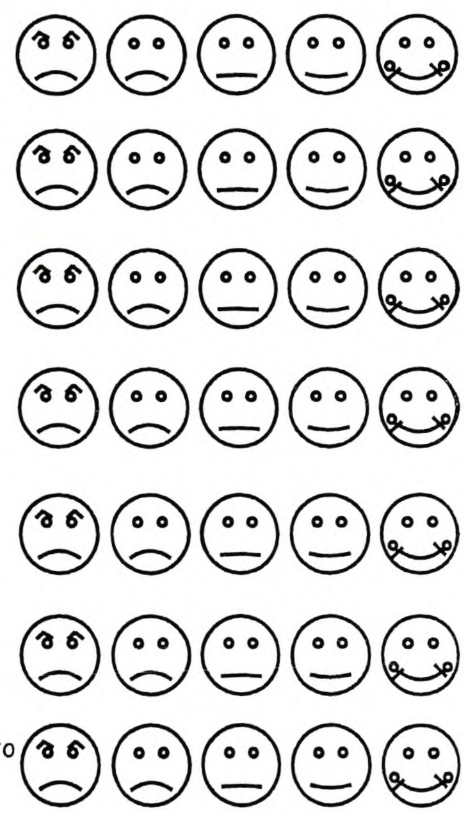
Questionnaire

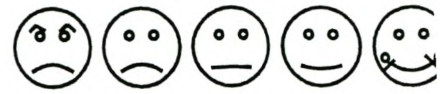
Please indicate by a circle how strongly you agree or disagree with each of the statements.

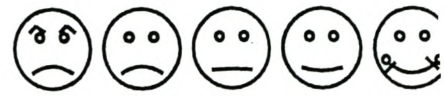
Use the following scale:



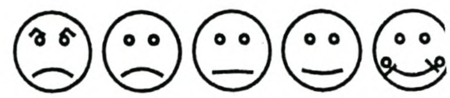
1. A plan is a useful tool to solve any task
2. In order to solve a task I first define the problem.
3. I never check my own work by myself.
4. I change my plan when it does not help me solve my problem.
5. The best way is to start working and only then define the problem.
6. I have no strategy to how to solve a problem.
7. I often decide what steps I am going to take in order to reach my goal.



8. I don't care about the rules when I solve a problem 

9. I can't solve a problem by myself. 

10. I use my plan while I am working. 

11. I try to gather information before I solve the problem 

12. What was the most difficult thing we learnt? ____________________

____.

____

13. What was the most interesting thing we learnt? __________________

____

____.

14. Please remark any other comment... ______________________________

____

____.

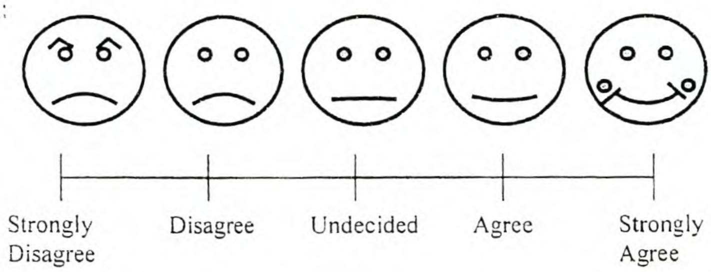
Thank You for Your Co-operation!

Name:

Questionnaire-Measuring and Matter

Please indicate by a circle how strongly you agree or disagree with each of the statements.

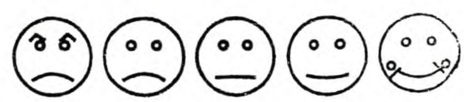
Use the following scale:



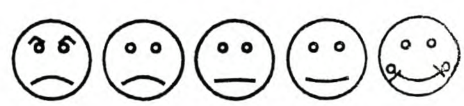
1. When I measure 100 ml of water with a measurement cylinder it will always give the same amount.

2. Tea spoons are a very accurate way to measure amount of sugar.

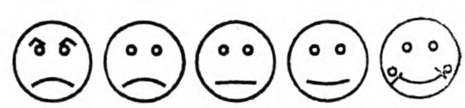
3. I feel that I measure now better liquids, weights, heights and temperature.



4. I feel I have practised measuring different things in the last lessons.

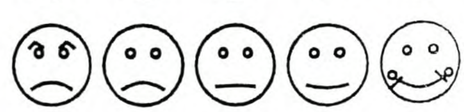


5. Matter can be found in three states: Solid, Liquid, Gas.



6. Measuring accurately is important when experimenting.

7. Continuum Scale is where we place an item on a scale between two extremes.



8. It isn't necessary to measure accurate amounts when experimenting

9. 100 ml of water will be the same amount even if put in different containers .

10. What was the most difficult thing we learnt? ______________________

____

____

11. What was the most interesting thing we learnt? ______________________

____

____

12. Please remark any other comment... ______________________________

____

____

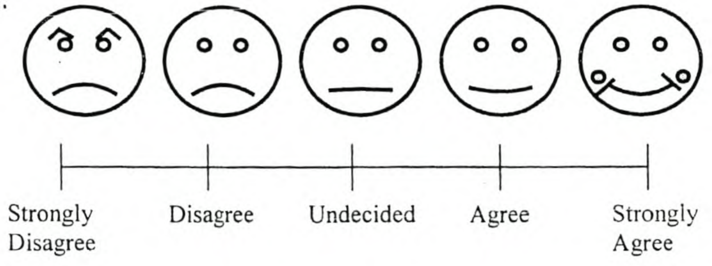
Thank You for Your Co-operation!

Name: ______________

Questionnaire-Compare and Matter

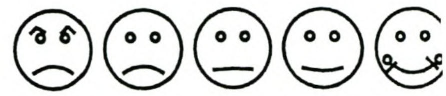
Please indicate by a circle how strongly you agree or disagree with each of the statements.

Use the following scale:

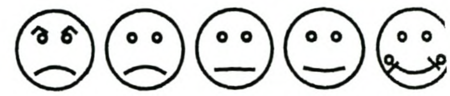


1. When we compare, we draw relationships between two things like objects, people, feelings... 
2. In gas, the particles can hardly move. 
3. I think it is necessary to decide on a parameter, that both objects share. 
4. When we compare we only look for differences. 
5. Matter can be found in three states: Solid, Liquid, Gas. 
6. Matter is made out of small particles. 
7. Continuum Scale is where we place an item on a scale between two extremes. 

8. I automatically make comparisons when I work.



9. In solid, the particles can hardly move.



10. When I compare, I look for what is the same and what is different.

11. Can you fix this comparison by changing only one word?

Men have hands. Birds have a beak.

12. What was the most difficult thing we learnt? ____________________

____.

____

13. What was the most interesting thing we learnt? ____________________

____

____.

14. Please remark any other comment... ____________________________

____

____.

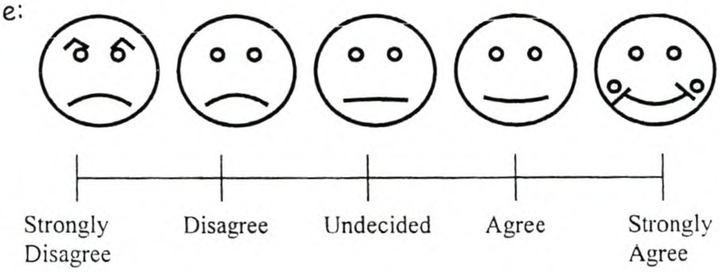
Thank You for Your Co-operation!

Name: _______________

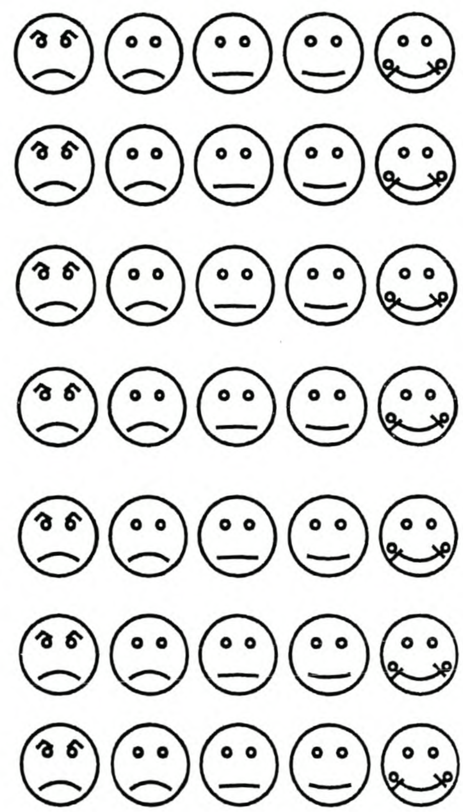
Questionnaire-Compare and Matter

Please indicate by a circle how strongly you agree or disagree with each of the statements.

Use the following scale:



1. When we classify, we first find differences & Similarities, then only we group.
2. In gas, the particles can hardly move.
3. I think it is necessary to decide on a parameter, that both objects share.
4. When we compare we only look for differences.
5. Gas particles can move freely.
6. Evaporation can happen only when boiling water.
7. Evaporation can happen in room temperature.

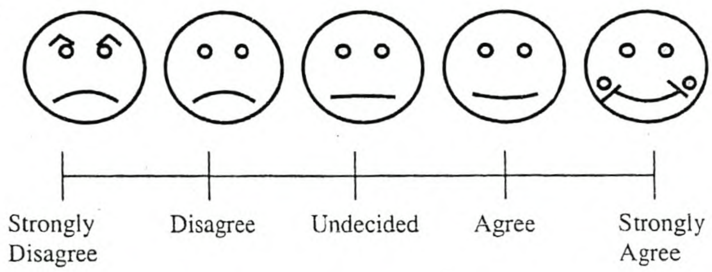


Name: ______________

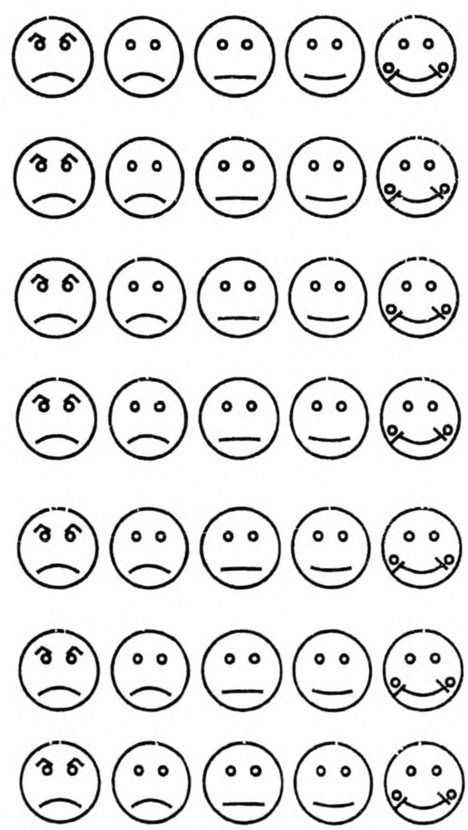
Last Questionnaire !!!

Please indicate by a circle how strongly you agree or disagree with each of the statements.

Use the following scale:



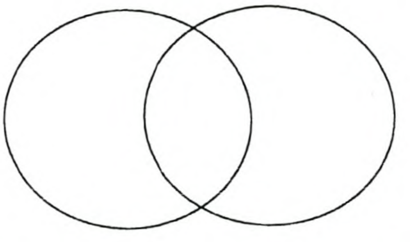
1. A plan is a useful tool to solve any task.
2. In order to solve a task I first define the problem.
3. I never check my work by myself.
4. I change my plan when it is not helping me to solve my problem.
5. Usually, I start working and only then I define the problem.
6. I have no strategy to how to solve a problem.
7. I decided what steps I was going to take in order to reach my goal.



8. The Venn diagram is a strategy to compare two objects.

9. When I compare, I look for what is the same and what is different.

10. Can you compare solids and gasses using the Venn Diagram?



11. What does happen to gas particles when opening a bottle of perfume?

____

____

12. What was the <u>most difficult</u> thing we learnt? ____________________

____.

____

13. What was the <u>most interesting</u> thing we learnt? ____________________

____

____.

14. Please remark any other comment... ______________________________

____

____.

Thank You for Your Co-operation!

8. I don't care about the rules when I solve a problem

9. I can't solve a problem by myself.

10. I use my plan while I am working.

11. I try and gather information before I solve the problem

12. I feel I have practised measuring different things in the last lessons.

13. Measuring accurately is important when experimenting.

14. Continuum Scale is where we place an item on a scale between two extremes.

15. When we classify, we first find differences & Similarities, then only we group.

16. The Venn diagram is a strategy to compare two objects.

17. When we compare, we draw relationships between two things like objects, people, feelings...

18. I automatically make comparisons when I work.

19. When I compare, I look for what is the same and what is different.

- Please write at the back what do you think of the science programme.
- Please write at the back what do you think of the skills we practised.
- Please remark any other comment...

Thanks and Shalom!

Name: __________

Grade: __________

This is part of planning an experiment.

The goal is to: ***Make the orange trees give less sweet fruits.***

After you gathered information from...

____

____

____.

You came up with 2 strategies. Please write them down:

(1) If I... ____ then...

____.

(2)If I... ____ then...

____.

Please explain 2 rules that will guide your work...

(1)____.

(2)____.

Thank You!

Name: ___________

Planning an Experiment...

A farmer came to your laboratory and asked you to help him produce Red Bananas...

1) Define your **goal**: ____

____

2) Where you gather your information from? ______________________

____

3) Please write down <u>**2**</u> **strategies**: (a) If I... ______________________

______________ Then... ________________________________

(b) If I... ____________________________________

Then... ______________________________________

4) Please indicate <u>**2**</u> **rules** and explain their importance:

(a) ______________________ it is important because: __________

____

(b) ______________________ it is important because: __________

____

5) How will you **check** your work? ____________________________

____

____

Think Well!

Please answer these questions: Name: ________

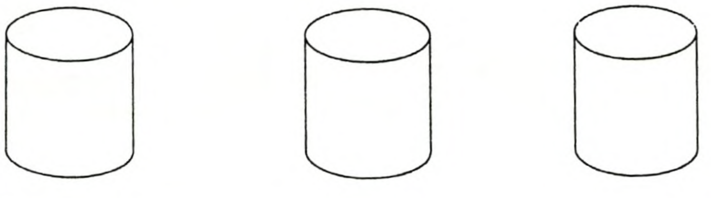
1. How do the Particles in Solid behave?________________________
____

2. How do the Particles in Liquid behave? ______________________
____

3. How do the Particles in Gas behave? _________________________
____

4. Drew a continuum scale and place those words in their proper place:
medium, tiny, enormous, large, small,

5. Please draw in these containers:



Full of Gas Particles	Half Filled with Gas Particles	Empty from Gas Particles

5. What is there between the Particles?_____________________________
____

6. please give two examples of:

Unit:	What does it measure?
____________	____________________
____________	____________________

Thank You... !

Last Quiz... Name:____________

1. As a scientist of the zoo, the manager asked you to "create" a giraffe with black and white stripes...

a. What is your goal?______________________________

____

b. Where can you find information? ________________________

____

c. What have you got?______________________________

____

d. What strategy are you going to use? ______________________

____

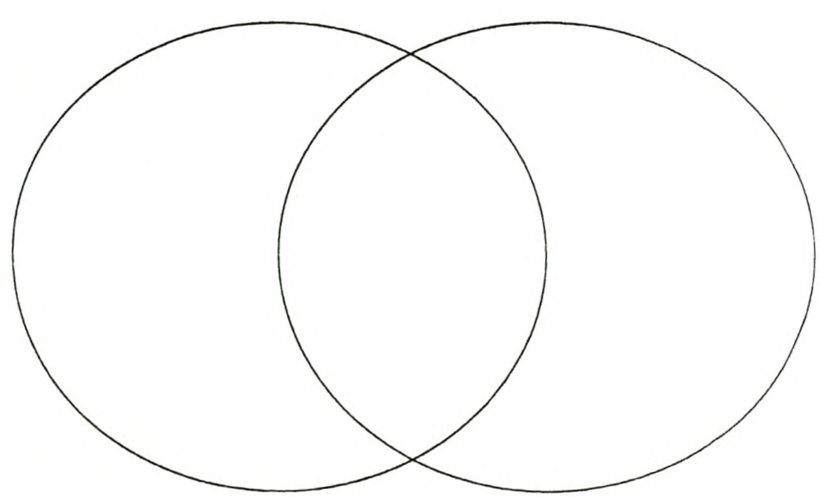
e. What is your guiding rules? __________________________

____

f. How would you check your work? ________________________

____

2. Please compare this two pictures using the Venn diagram: try to find as many parameters as possible...



3. Use the linear diagram to classify these things into 3 groups: solid, liquid and gas.
   - Cheese
   - Books
   - Coffee
   - Oxygen
   - CO2
   - Air
   - Pencils
   - Milk
   - Apples
   - Apples juice
   - Trees
   - Laughing gas

4. Fill in the missing words that describe the processes needed to change from phase to phase.

$$\textbf{Solid} \quad \underset{?}{\overset{?}{\rightleftarrows}} \quad \textbf{Liquid} \quad \underset{?}{\overset{?}{\rightleftarrows}} \quad \textbf{Gas}$$

Thank you and good luck!!!

Last Quiz... Name:___________

1. As a scientist of the zoo, the manager asked you to "create" a giraffe with black and white stripes...

a. What is your goal?____

b. Where can you find information?_____________________________

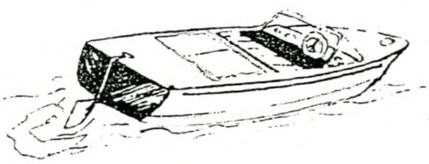
c. What have you got?____

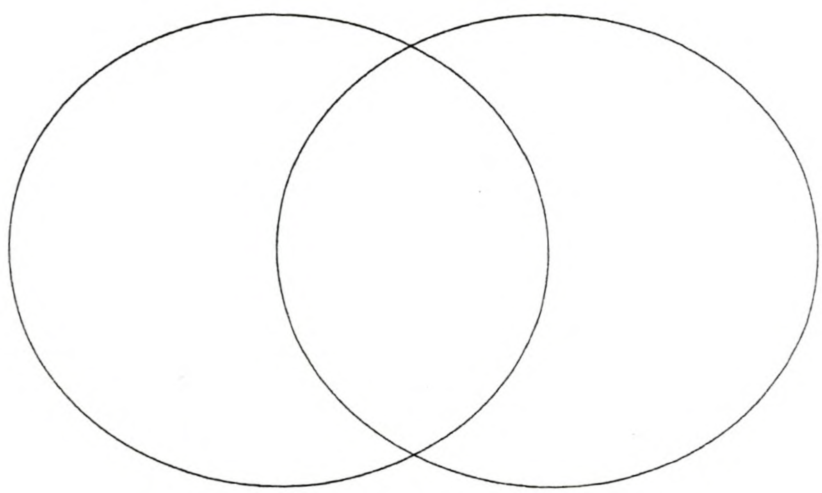
d. What strategy are you going to use?__________________________

e. What is your guiding rules?_________________________________

f. How would you check your work?_____________________________

2. Please compare this two pictures using the Venn diagram: try to find as many parameters as possible...





Appendix F

Interview with Mr. Noel Carr-the teacher of the grade 6 classroom.

As part of this curriculum evaluation of the mini programme I wrote for teaching thinking skills in science using some of the instruments of IE, I need your input since you observed the whole process in the classroom.

The aims of this programme were:

1. Contribute to the development of thinking skills in biological-science topics.
2. Contribute to the transfer of thinking skills to nonbiological-science disciplines.
3. Increase student engagement in science class.
4. Influence the classroom learning environment.

- Before we start maybe you can describe briefly the children attending this class in term of cognitive and behavioural abilities.

1. One of the goals of this programme was to teach thinking skills in science like compare, observe, measure, classify, experiment, etc. to what extent in your opinion this goal was accomplished?
   - If you had to rank the accomplishment from

excellent	good	fair	poor	very poor

     what will you give it?
2. Were the level of the skills and the use of them suitable for these children?
3. What changes have occurred (if occurred) in students skills level and use?
4. To what extent do you think skills will be used and transferred to other subject meters or situation in life?
5. Which skills you think they will use frequently? Can you rank the skills?
6. Have you seen already changes in the use of one of the skills? Which?
7. What changes have occurred (if occurred) in students knowledge base?
8. Did they acquire any knowledge? Can you rank the mount of knowledge transferred relative to the time (one term):

excellent	good	fair	poor	very poor

9. Was the knowledge level suitable for these children?
10. Was the knowledge interesting for these children?
11. What do you think about the three outings we had?
12. Was it an educate experience?

excellent	good	fair	poor	very poor

13. Was it enjoyable? | excellent | good | fair | poor | very poor |
14. What do you think about the tasks and activities they had to do?
15. Was it an educate experience? | excellent | good | fair | poor | very poor |
16. Was it enjoyable? excellent good fair poor very poor
17. I have used a few pages from IE different instruments. Did it contribute to their understanding of the skills?
18. Was the use of them sufficient?
19. Would you have used it differently (more / less)?
20. How was the bridging from the instruments to the science topics in your opinion?
21. Did this programme contribute to their attitude towards science as a subject meter? To what extent? Contributed | a lot | good | fair | poor | not at all |
22. We discussed and reflected the lesson every time approximately throughout the term. Could you see, feel any outcome from those discussions?
23. Was the programme flexible in your opinion?
24. It bring is to my way of teaching. Can you describe me as a teacher?
25. How was the level of creativity? | excellent | good | fair | poor | very poor |
26. How was the level of flexibility? | excellent | good | fair | poor | very poor |
27. How was the level of enthusiasm? | excellent | good | fair | poor | very poor |
28. How was the level of listening to children's problems? | excellent | good | fair | poor | very poor |
29. At last : how was the programme organised and facilitated?
30. Would you recommend any changes to this programme?
31. Would you recommend this programme for next year?
32. Do you think the children enjoyed it?

INTERVIEW (*QUESTIONS AND COMMENTARY BY INTERVIEWER IN ITALICS*)

The basic reason why I'm interviewing you, is because as a part of the curriculum in the evaluation that I'm doing on the specific programme. I want your input, because you are a science teacher, you know the kids and, you are in it all the time, you observe what we are doing and just answer to the best of your knowledge as you think it should be.

I'm going to read the aims of this programme, for you to hear what it was all about. It was to contribute to the development of thinking skills in biological and science topics. To contribute to the transfer of thinking skills to non-biological science topics, science fields and topics to non-science skills and disciplines, to interest student engagement in science class and to influence the classroom learning environment. That was my four goals.

The best thing for me will be that you would describe the children attending this classroom in general, what are their main problems, etc.

What we must understand is that Pro-Ed House is a school very different to the normal mainstream school. In fact we only deal with children, who for whatever reason, are not psychologically secure or comfortable and are not achieving scholastically in the mainstream. So they've one or other learning problem or difficulty and then they come to us for a period of 2 to 3 years, on average 2, 2½ years and we attend to the problem, whatever it may be for that individual, with a maximum of 12 in a class and then they go back to main stream where they have support mechanisms in place to further assist them. If we look at the dyslectics of this world, they would have coping mechanisms to assist them and in this way return to the main stream with self-esteem (no 1) in place, the weaknesses that they came to us with and that were identified through the psychometric testing material by either one of the two psychologists, Dr Worrel or Sharron Hartenburg and yes, that would be it. So the children would be a tension deficit, having an activity disorder, dyslectic, we have one lad who've got Asperger, understanding of Christopher and his particular problem. So we've got a broad mix of children, but most of them can be categorised as children with learning disabilities in the areas of reading, studying, emotionally having problems and that is what we work on. Self-esteem, self-confidence, using the strengths that they have to bring together the weaknesses.

One of the goals of this programme was to teach thinking skills in science like how to compare, measure, collecting data, experiments, classify etc, etc. To what extent in your opinion, this goal was accomplished?

If I look at them individually, look at observing and we look at the outings that we had, we may have had something very specific on worksheet which was an act of observing, but that led to other things, observing as well. So what the goal was for that day, I would say we achieved the goal of observing very well, but there was a transference or bridging to other things. I was almost sure that they immediately internalised the act of observing. The activity was a good thing for them, they went out there, enjoyed the outdoors, enjoyed the activity of collecting and then observing. If I look at measuring, referring to what I've said just now, possibly from the same activity of observing. Classifying, we saw that they could do very accurately, after several sessions with you. There are no doubt in my mind that they clearly understood what classifying was and could take it from, what was given to them as a lesson, to other areas other than the content of that specific lesson and apply the issue of classifying to it. Recording and collecting data, that they did, enjoyed, did it actively, so I said it was good/excellent. Interpreting data – I don't think they always got… Their ability to, how should I put this…

Interpreting, that we did'nt do so much, we did'nt stress it….

I think the controlling variable, we saw that with the tea experiment. It could have been one way or another, certainly your solutions to whether or not an example where they clearly understood, you could only give it a excellent rating. Experimenting – as far as the children are concerned, there are no doubt and I think the video material will show that they enjoyed the activity, playing around as young scientists in a not so well equipped laboratory, but sufficient enough to be it here or outdoors. So I think, on all those issues, it is certainly good to excellent in the most cases and mostly just excellent.

Were the level of the skills and the use of it suitable for the children?

When you say skills, you mean…

Was it to their level of cognition, or was it to high or to low?

For the majority definitely. If we looked at people like, Sandra and Ty, we understand that Ty was very young. So, at the bottom end of the scale, you probably excluding for experiment purposes, for control purposes and for Sandra, she is generally not always …, one is going to get what we trying to get to her the first time.

How was it for Tommy?
Tommy may be bored by it, if you took it to another level for Tommy, he might have been challenged by it, but as I said, in the main, most children must pitch correctly for the group. Call it a just group, for example, you've got 11 and 14 year olds in the same class. So in the main, look at the distribution curve and the majority, must pitch correctly to all of that.

What changes have occurred/if occurred? on the student's skills level? Did they use it better as far as you can see?

Let me start off with the very first lesson we did with that chart and the thing that sticks in my mind and I can say that this has been huge by that they verbalised it, obviously internalising is, what have you got, gather the data, what can you work with? and then than extractivate from that. I only have these 3 points, but somebody else must have 5/6 gathered points and they can now predict or infer from that, so they are using it. There is no doubt in my mind that skills taught are being applied and hopefully they will continue to use those in the class.

But you said the transfer in other subjects are.....

I'm referring not only to the acquisition of the skill, but the bridging from a specifically lesson to life in large, so that we would be doing maths for example. Have you got all the rules, have you gathered all the data? That is not quite gathering data, but they are thinking along lines of gathering, so they are using a skill that was taught very recently and so, but you haven't got all the rules – when you do multiplication or fractions, you got to have this, this and this. So what they're doing is they don't perhaps do gathering, but applying the skill of gathering to say: I know I need 3 of those things, but I've only got 2, I don't remember the third.

We are now moving to the knowledge that was gained. So do you think that the aim changes/occurred in the student's knowledge. Did they gain knowledge?

Lets say they heard more about for example the animal kingdom or the types of kingdoms, that there are 5 kingdoms – yes, then there are no doubt in my mind that (coughing).... I think, for example people like Nigel comes to mind, for example. He will tell you when a solution happens in detail, in very broken english will share with you that there has been a acquisition of knowledge. He can apply that, whether he's making tea or not, with or without sugar. So definitely, again for the most of the children, with one or two exceptions, but the most, there was an acquisition/acquiring of knowledge. And they will take it wherever they go. I think that has happened because of the way you went about it, the way that you structured the lesson, whether they were allowed to get hands-on and use the experiments to arrive at the conclusions that you have seen.

Can you mark the amount of knowledge that was transferred, a lot or very little. Was it a lot of knowledge, a fair amount of knowledge or was it a very little amount of knowledge compared to what you can do, lets say in one term...?

Because of the problems that these children have, contents stuff like science, biology, history and the like, doesn't play a major role in there so-called redevelopment over the 2 or 3 years that they are with us. We concentrate on self-esteem, image, literacy and numeracy and what you are referring now, plays a secondary or further down the road role. We would do less then what you covered in the same time period and actually another important aspect that is coming out of your teaching here, is that when we believing that they can't cope with the quantity of material offered to them in the science through your lesson system compared to what they are going to have to do in high school main stream. So I'm saying, they covered more than I would have planned for the exact same lesson. The belief being, because they've got reading and spelling difficulties, they would cope less, and yes, that may be, but I think the way we gone about mix of read and experiment hands-on, show at the end of the day that they are able to measure the content in their minds and their brains. That would then be quite significantly more than what would have been planned for on our term planner for them. We seldom get, for the 11 or 12 weeks in the term, we plan science, biology and history for that term, we seldom get through those 11 weeks as planned for....
You did it better then we do...

And the knowledge level…was it suitable for the kids?

It was interesting for them, It certainly was. Again if we would go back to your video material, to see how exited they got about certain of the lessons, how animated they became, how they suddenly enjoyed, and as I've told you several times, its approaching your arrival time and already they're telling me that you're coming. You're about to, you're here…So, yes I think….

Anything else about knowledge…

Just that they suddenly enjoyed the content as presented. I think throughout, this is the one thing that can be said, that can be highlighted throughout that there was participation and that participation was coupled with that "I enjoyed myself in this class". with the 1 or 2 obvious exceptions – there will always be 1 or 2 exceptions….

What did you think about our outings, 3 outings, 2 to Rondebosch Common and one to the Aquarium?

There I had to learn one or two things, since we don't do too much of that because of the behaviour aspect, for us it is a problem. Remember, they come to us from main stream, not because they've got a learning disability, but because they have a behaviour problem there, so they leave, because they cannot cope socially and emotionally. So when we consider things like this, it's pretty much controlled. We've got 2 teachers, 5 parents, we go out, on site wherever…. It is ratio of sort of 1 adult to 5 children to make sure. Here we saw with your class that there was really only one teacher – I was very much in the background and we did cope and the lesson for me was that if we had planned a little more carefully, we might not have had and having learnt from that experience, I know now for next time, we don't need 1 to 5 ratio, we can go out there, but we will set the parametres up front. So for example, we would say to them that from the point that we decide that this would be the field class is, 50 m diametre is the most you can go, so in your pairs work, count 1, 2, 3… up to 50, they turn around and face the teacher and the central focal point of the class and they would back from there. That was the one thing that I learned from your experience of the outdoors there, that perhaps there should never be more than 2, definitely not more than 3 and that they actually stop them from going into different directions, because the nature of their problem here, when you get 2 groups together, they lose focus on what we meant to be doing out there and this would be a guideline that I would put down in writing for all the teachers to say that you could go successfully to Rondebosch Common and this is what Nilly and I've found would be good guidelines for taking children with that kind of problems that our children do have out into the field.

Was it an educating experience for them, not just fun.

It was fun definitely.

Was it also educating for them – did they learn something?

I would say what they learned there, would have been an extension of what was learned in the classroom first. The short answer is yes – learning occurred and although I think on the first outing, they saw it more as a fun-thing than a learning-thing. Learning occurred, there is no doubt in my mind that learning didn't occurred and would have been an extension of the stuff that was done in the classroom.

We are moving more now to the tasks and activities that we were doing in the classroom and I'm not referring now to the Feuerstein work, just lets say the quizzes that we have done, the debate, this type of things that they had to do. In general, what do you think about it, was it, I'll separate 2 questions. (1) Did they enjoyed it, were they engaged to it?

I think in short that throughout most of the children enjoyed the activity. Then you have children with writing difficulties/problems, I found the lesson sheets/notes weren't too lengthy, too cumbersome in terms of their ability to do the work – in other words, there wasn't much on a work sheet that would overpower – "I cannot do this..." feel traumatised by a mass of stuff. It was sufficiently scant (=barley sufficient) to keep them focused, because remember, our biggest problem here is focus and throughout we saw that the children, once they got involved individually or in their groups, we able to maintain the focus which is a major thing for us here. You can hold the kid's attention for 3 to 4 to 5 minutes, you have achieved enormously...OK. In this instance, the video material will show you, in the animated way, they got involved and they did their work sheets and solely enjoyed it. So it was very pleasing for me to see that children with reading and spelling problems getting involved with a given worksheet.

In terms of education – it was a learning curve through the work sheets, was it reinforcing what you were doing?

Yes, it was indeed and for example people like Nigel would be quick to come to speak and Nigel is one of several of the learners who would recall from a past science lesson, which would include the worksheet. He would show that he has acquired and attained the knowledge and would went forth, because of a question that you or somebody else may have asked in the classroom.

Can you rank it from excellent to very poor if you have to?

I think it has been be rated between good and excellent, because for me the important thing is, who at this moment in time is not doing what they are supposed to be doing. We are looking at it more like say Ty... Ty is very difficult to keep track off and if you've got Ty focus, you're doing a fine and a wonderful job – an excellent job. I think for most of the children, sometimes a little loud, you have to look at all of that, then I would say, it was excellent. Never forget that we're not dealing with your average child in a normal main stream school. You've got exceptional children her with all sorts of emotional, social and scholastic problems.

And in terms of enjoyable (?)

Throughout, you could ask me that question on any aspect of the lessons that you gave and I've got to answer that they thoroughly enjoyed it.

Now we are looking at the instruments. We used a few of these instruments, basically organization of dots. collecting data classification in comparison, but I've taken 1 or 2 pages from the instrument itself and then we move/bridge it to science and we kept on from there. We didn't change the level of the instruments. What did you think about that?

I thought it was excellent and I think that we looked at the, I think the most significant one for me is the one I remember well, was the Venn diagram. It came to them like THIS. They could immediately apply the knowledge gained through bridging to the science lessons that followed and followed the classification. So I would rate that as absolutely excellent.

Do you think there was a need for more instruments?

Personally, I wouldn't say there was a need for it, I would say that what would have happened is that, had there been more, they might have benefited more. I can't say that specifically throughout the lesson, they seemed so comfortable with the few that we did and were able to bridge and go on with it, in other areas of their lives, other content material maybe 2 or 3 more may be added to that.

How was the bridging from the instruments themselves towards science topics?

I thought very good, excellent.

Would you use it more?

Indeed.

Would you use it here?

I'll give it a very definite shot, for many reasons. The first one is, I really have had the opportunity to give it any time in the classroom and I've seen how it worked exceptionally well with the children, in the short time that you've been with us. It just make sense that having done the course, it could try and apply it in the same successful way you have, with the grade one younger that this, the 10 year olds.

Would it shorten/longer the time for you to work on specific knowledge, problems, etc.?

It is difficult for me to answer that one right now, because I don't know what the content material would be, but I should imagine, if I have to give an answer yes or no, I'll say, it would have the same effect that it had with this class.

Has the programme contributed their attitude towards science subject matter?.

Yes, without a doubt, there is no doubt in my mind. If we go back to the other outing that you organised to the Aquarium and what has happened since (we've briefly mentioned that earlier). I have no doubt that as a direct result of what you did, those children, at least 3 to 4 of them, 3 definitely would get involved and are going to get involved with the aquarium, the junior biologists programme and although they would not be at this school next year, I certainly have every reason to believe that they are going to go on and what you did for them over here, contributed to their much better and keener understanding of the world of science, whatever else.

We had a discussion almost after every lesson, could you see or feel any outcome from what we have discussed afterwards. Could you see a change in what happened in the class after we discussed something?

Every lesson one could perceive a change, except one, I can't remember which one it was, there was one lesson where they were either too tired or the weather was too hot or they just, I can't recall which one it is. The mention of just one lesson is a credit to you, rather than 10 lessons that did work. I would say yes.

I don't mean a change in their attitude, but the change from my side is an outcome of our reflection, because we reflect it up to every lesson, did I apply it?.

What we discussed and what I've shared with you that could have been change, yes of course, there were change, for example the mediating phrases, giving people the opportunity to share with the next one, ask the question and then give them the opportunity to share. The answer to that is yes. From the teachers perspective, given the discussions that you and I had as teachers, there were changes to be seen, follow-up, following lessons from your side.

Did they benefit from it?

Yes.

Was the programme flexible enough? The summary, the lessons that I wrote in advance, etc. the whole programme throughout the term, was it flexible?

Yes, to give to one example that it was flexible. Sometimes you couldn't finish the whole lesson, but it didn't mean that there wasn't a meaningful connection point further on down the line. So it was flexible if you didn't get through the lesson today, you could still in a meaningful manner pick it up in the next lesson and carry on. But more than that would be I suppose, we could diverse whether we're talking about fishes, insects in the field or the aquarium over there, we could have had either one or both and perhaps anything else – by that I'm suggesting that it was flexible enough to jump from a grasshopper to a whale.

Would you mind to describe me as the teacher?

When we first planned this term project, you wanted no teaching, because you thought that there was going to be a serious communication problem because of your own perceived inability to communicate effectively in English, and maybe 1 or 2 other factors, maybe your accent or whatever, I don't know. Now, having a look at that and reflect on everything we've just spoken about in the last half or ¾ of an hour and what we said has transpired, then you underestimated your own ability and this is the proof on video to show that you coped more than adequately with your perceived language inability and I never taught a single lesson and initially the idea was that I was going to teach and you are going to do 1 or 2 and if I'm going to put this on video. I'm saying this to you now – I encouraged you to teach all of them and you did exceptionally well. So for a teacher who thought she couldn't do it to one who has ended up with a more than excellent result given all the perceive imperfections from your side, I think you did exceptionally well. Let me add, if you would to ask the same question to all of the children, should we have Ms Galyam here, if I'd say no she is not and that is my decision, they would shout me down and they vote you in. Honestly from the hearts from each of those little boys and girls that you had the privilege to spend the 3 months with, that we had the privilege.

Was it creative enough? How was the level of creativity if you have to rank?

Yes, I wouldn't rank that as excellent or good, I would say that was fair. By that, let me try and qualify that. In the beginning some of the lessons, there was too much one-way track from the teacher's side. That changed later when there was anticipation through worksheets and that took the teaching away from you. No… Maybe I should review this one, because I looking at experiment. OK… My gut says to me it was fair to good.

Was I Enthusiastic?

I think very enthusiastic, I you carry 5 litres of water round a big place like this, etc, you've got to be reasonably enthusiastic or more... I think your enthusiasm, that which could not be seen, was a direct result of your inability to communicate through the English language. That was all; you would be eager to say something for example and you would stumble over words or means of expressing it. If they could all speak Hebrew, I have not doubt that one would immediately see a level of enthusiasm that possibly was for any other viewer, somebody who is not in the know like I was, I was there. If you should just gave this to somebody, class of students to view, they would say that she is not very enthusiastic, maybe and that would be because of the language medium that you had to use.

How would you rank it?

I would say excellent.

Excellent? I thought you say you could see sometimes...

I would say, you can't get away from the fact that you were enthusiastic, the fact that you were not able to express it maybe as brilliantly as another english speaking person, it is no fault of yours, I'm saying that anybody viewing the video might not see that and disagree with me, but they were not there from lesson 1 to see what was happening, how you went about it, what you did, how you put …. We phoned/email and we spoke about it.

Was I a good listener to the children's problems?

That is a difficult one for me to answer. I can't say yes or no to any of that. I would say, because of their enthusiasm, you have 5 or 6 hands going up at the same time. You would point to a person and listen, that's is what you're asking me, you listened very carefully and as we spoke and reflect on the lessons, from lesson 1 onwards, initially there wasn't a mediating, later the mediating came more and more and played a greater role. Then I would say, yes, you did listen very well. You gave opportunity for the learner to express what he/she wanted to express in a meaningful way.

How was the organisation, implementation, etc of the whole programme in terms of equipment, etc?

Given the resources that we both had little of, you did exceptionally well, I would say excellent.

What changes would you recommend for this programme if you had to do it?

My first one is always the crowd control story, because we've got this issue with behaviour problems which as I said, they arrived here first and foremost, children who are displaced because they have behaviour problems and they leave us with the behaviour and the demystification of their problem, behaviour gone and then equipped with the strategies and coping skills and going back to main stream. So for me the first thing that any teacher in this school environment would consider, is that aspect. How do I get them out there? That is not so much a change as it is a recommendation because the second outing we went to, we did implement those trades, we did tell them from the centre point, 50 paces, turn around, come back. So it is not so much a change as a recommendation that all future trips, that they definitely work in pairs, that we set clear parameters for them, clear guidelines, definite set of rules as to, eg. Don't move the log too much, don't move to far away, handle with care, turn the brick over with your foot or a stick or another rock. I think just from the crowd control aspect, because of the behaviour problem, that is the one thing.

This is mainly for the outings, what about the problems in the classrooms?

The mediating aspect, Dr Worrel would tell you that you are a good mediator after 2 years of practice. You've been here exactly 3 months and we saw with the after-lesson discussions that we had, that it did come in and that's the only other thing I could think of. It's not something that comes naturally. As you know from my diary, which I don't have now, I've got them pasted on the front of my book as a constant reminder to me. I used to have a full page on my desk here last year as a constant reminder to me that these are the things to bring about effective, efficient learning through this mediator learning experience.

So you say: crowd control and increasing the mediation and I can add using of instruments more often, etc.

Yes.

In terms of content and knowledge.

Fantastic, as I said earlier. They enjoyed the kind of content that you gave them. It was varied, anything from... The classification, triangles and squares and from that to grasshoppers, possible snakes and other spiders to the aquarium and things like that. There was varied content and all of that they enjoyed, they thoroughly enjoyed learning about all of that.

And the knowledge, basically the same, and the skills that we have learnt, would you choose different skills? Those were the skills that were chosen by the American Association for Science. Would your choose/implement or stress different skills?

I don't know what the content material is for next year's lesson. I don't think so.

Then I'll ask you again if the children enjoyed it....?

There is no doubt in my mind, there is none, the video will show, what the video doesn't show, I'll just know from your absence here and the constant reminders t

Interview with Mr. Noel Carr-the teacher of the grade 5 classroom 2003.

As part of this curriculum evaluation of the mini programme I wrote for teaching thinking skills in science using some of the instruments of IE, I need your input since you observed the whole process in the classroom.

The Purpose of this Study:

1. Contribute to the development of science thinking skills in learners with special needs.
2. Contribute to the transfer of thinking skills to other disciplines.
3. Help learners with special needs to reduce their common characteristics such as distractibility, passive approach to learning, ineffective learning and memory, poor self-concept, impulsive behaviour, and low motivation to succeed at academic tasks (Ormrod 1995).
4. Increase student engagement in the science classroom.
5. Influence the classroom-learning environment.

- Before we start maybe you can describe briefly the children attending this class grade 5 in term of cognitive and behavioural abilities.

1. One of the goals of this programme was to teach thinking skills in science like compare, observe, measure, classify, experimenting and planning. To what extent in your opinion this goal was accomplished?
   - If you had to rank the accomplishment from | excellent | good | fair | poor | very poor | what will you give it?

2. How was the development of thinking skills as compared to the last year? Do you think it was: | better | the same | worse |

3. Were the level of the skills and the use of them suitable for these children?

4. What changes have occurred (if occurred) in students skills level and use? Do they use them | better | the same | worse |

5. To what extent do you think skills will be used and transferred to other subject meters or situation in life? Do they use them occasionally?

6. What changes have occurred (if occurred) in students knowledge base?

7. Did they acquire any knowledge? Can you rank the mount of knowledge transferred relative to the time (one term):

excellent	good	fair	poor	very poor

8. Was the knowledge level suitable for these children?

9. Was the knowledge interesting for these children?

10. How was it as opposed to last year? Better/worse, more / less,

11. What do you think about the outing we had to the science center?
12. Was it an educate experience?

excellent	good	fair	poor	very poor

13. Was it enjoyable?

excellent	good	fair	poor	very poor

14. What do you think about the tasks and activities (worksheets and experiments) they had to do?

15. Was it an educate experience?

excellent	good	fair	poor	very poor

16. Was it enjoyable?

excellent	good	fair	poor	very poor

17. I have increased the usage of pages from IE different instruments. Did it contribute to their understanding of the skills?
18. Was the use of them sufficient?
19. Would you have used it differently (more / less)?

20. How was the bridging from the instruments to the science topics in your opinion?

excellent	good	fair	poor	very poor

21. Was it better than last year?

a lot	good	fair	poor	not at all

22. Did this programme contribute to their attitude towards science as a subject meter?
To what extent? Contributed

a lot	good	fair	poor	not at all

23. We discussed and reflected the lesson every time approximately throughout the term. Could you see, feel any outcome from those discussions? Did the reflections caused any change?

24. It bring is to my way of teaching. Can you describe me as a teacher? As opposed to last year? Any improvement?

25. How was the level of creativity?

excellent	good	fair	poor	very poor

26. How was the level of flexibility?

excellent	good	fair	poor	very poor

27. How was the level of enthusiasm?

excellent	good	fair	poor	very poor

28. How was the level of listening to children's problems?

excellent	good	fair	poor	very poor

29. At last: how was the programme organised and facilitated?

30. Would you recommend any changes to this programme?

31. Would you recommend this programme for next year?

32. Do you think the children enjoyed it?

Nilly: Hi Noel. So the interview today is about two main things. One is the grade five class, the children in the grade five and the programme we have done with them. The other thing I will be asking is to compare actually this term with the previous term that was given last year, and see if there is any improvement or change or anything like that. So those types of questions will be asked.

Noel: OK.

Nilly: OK, so maybe... the best thing will be that you will describe how do you perceive the grade five learners. What type of problems the children have?

Noel: A wide range of different scholastic problems. Children with great discrepancy in verbal and non-verbal scores. We are looking at children who have emotional problems, we are looking at children who do not have the intellectual potential really to main stream: 1 or 2 of them are way below the average. 2 in fact out of the 11. We are looking at children who have specific learning problems in areas of reading, spelling and math. That's a big mixed bag of problems. We had something similar, to make the first comparison, with all the boys and girls of last year same time, but an over all general feeling about the way you went about it this year compare to last year, is to say that (pause)... Somehow I get the feeling and maybe your results will show that we were more successful with this group, despite them being younger. What comes into mind straight away is the mediating aspect from your teaching side of things...
There is no doubt in my mind that a lot more of that happened and as w were discovering the little teaching issues throughout the term, you were able to incorporate my thoughts on a particular lesson in the next or in the ones that followed there after.
So really generally speaking, that is how the sum up of the group that we had this year compared with the last year.

Nilly: OK. These are some of my purposes of this research in general. I'm going to target each and every point- so first is 'to contribute to the development of science thinking skills in learners with special needs'. So the sets of the first questions will be around this one.
That was my goal and I've been teaching them: comparing, measuring, classification, experimenting and planning. These are the thinking skills that I actually tried to mediate. If you have to rank the accomplishment from what you feel about these skills, how would you rank it? Did I succeed in teaching them or not?

Noel: to a large degree and in almost every aspect we can say, we were succeeding in achieving all of these, except in the case of the two learners that have some difficulties. We were also successful but not to the same degree that I believe the others got. So, given those learners, they did learn, but if one is able to qualify the difference between those particular individuals and the rest of the class, there will be a difference. But across the board my feelings is they definitely benefited from it.

Nilly: From the skills?

Noel: Yes.

Nilly: and they manifested them also?

Noel: Yes.

Nilly: How was the development of thinking skills as compared to the last year? Do you think it was better, the same, worse?

Noel: Again I must say this: without being able to give a concrete example I have a gut feeling that these children learned better than last year.

Nilly: Were the level of the skills and the use of them suitable for these children as I presented it to them?

Noel: Yes without a doubt. I think you were very good in getting to the level, maybe that they were younger group than the last year.

Nilly: What changes have occurred (if occurred) in students skills level and use? Do they use them better/ the same / or worse?

Noel: OK, this group has not used them (the skills) before at all. Your presentation to them would be the first time...

Nilly: so you think they have learnt?

Noel: Look, I can take it to another level where they are using it in another areas in the classroom...

Nilly: This is my next question: To what extent do you think skills will be used and transferred to other subject meters or situation in life? Do they use them occasionally?

Noel: Yesterday, to give you a classical example, the social skill teacher was in here and I happened to be here, sitting in the classroom. She broke them into 2 groups and she gave them two specific things to attend to. I asked here permission to just add one thing and that was: we stopped the two groups and we said to them: remember what you have learnt with Nilly, now define your goal: what does group no. 1 have to do and what does group no. 2 have to do. Now, look at the information you've got and decide on what still you need and on what strategy you are going to follow. And work out the rules. And we backed off. They new EXACTLY what to do...she asked them to build a house and they had to nominate who is going to be the plumber, the electrician, the brick builder...
I don't quite remember what the other group had to do but it was something completely different. They had to develop through group discussion a logical sequence of events... What was interesting is that one person in each group said: "Define your goal, What are we suppose to do? And having spoken around defining the goal they came up with a clear

definition, so in the one group in particular it wasn't one clear definition- it wasn't just building a house, and they had to clearly define their goal first.
But the point is that the social teacher achieved what she wanted to, she got them all involved and they followed what they learnt in the class with you.

In math we used it (the linear diagram) for fractions. When we discussed fractions, what type of fractions, they came up with the notion there are two types: common and decimal fractions and under the common fractions there are 'three legs' which would involve the mixed fractions, the proper fractions and the improper fractions, and discussions around it. But again they were following the kind of stuff that was taught to them by you in the classroom.

Another time we used it is in our phonics class- again we used the liner diagram to show how what we learnt in science class- in your class- can be used in several other areas: in social class, in Maths, and I think you got copies of the phonics ...

Definitely, there is transfer and we have seen it in three different areas...

Nilly: What changes have occurred if occurred in students knowledge base?

Noel: If we look at **Tk** who clearly remembered things like solid, liquid and gas. It is incredibly difficult for her as a learner with severe problems to come through... she can snap, she knew there was something there, not always answering correctly, but she had a recall. And the recall is only a result of the way you went about the science lesson and that is the worst level...
I'm sure the videos will show, with the other children, people like **A** for example, that came as a real surprise to you, even yesterday there was a recall from weeks ago. I can only describe as to what happened in this classroom, science, the thinking skills, the applications of those to the content and the ability of as many of the other learners to recall and to do it so accurately...so definitely...

Nilly: Can you rank the mount of knowledge transferred relative to the time (one term): excellent, good, fair, poor, very poor/

Noel: Excellent.

Nilly: Was the knowledge level suitable for these children?

Noel: Giving the nature of the learners that we have in this school- the kind of children we are dealing with, I can only say it was excellent. Because what we do is... we don't spend much time on the content. Because of the other subjects like literacy and numercy take the priority over... But we had two of your sessions every week most of the term, and they have problems writing, they have problems reading, they have problems with recall but they can talk more than adequately about the content they have learnt with you. They stood there (shows the wall where the poster describing the different lessons and content used to be) and went through things in front of the pictures or drawings and they were able to elaborate on the content. Was it suitable? Yes, yes, absolutely…

Nilly: Was the knowledge interesting for these children?

Noel: They loved it.

Nilly: How was it as opposed to last year? Better/worse, more / less?

Noel: Better. I think it was better than last year. I think that between us we had the experience of last year, and your skills in the area, you are better equipped to deal with them.

Nilly: Last year I taught two topics: solutions and food and feeding. This year I taught only one topic that was Phases of Matter. In your opinion, is it better to teach only one main thing or is it better to teach two different topics?

Noel: Oh, no. I think one thing. My feeling is that one thing is better.

Nilly: We had three outings last year. This year we had only one. What do you think about the outing we had to the science centre?

Noel: Look, the centre itself without anything happening in the classroom is a very exciting place to go to… it's an incredible stimulating place because of all the science things that can be experienced by the learners. But I also think that your application, by the little worksheet that you gave them sort of kept them on track- took them through the various things that you wanted from them, very successfully.

Nilly: Was it an educate experience? Excellent, good, fair, poor, very poor?

Noel: Yes, Excellent.

Nilly: Was it enjoyable? Excellent, good, fair, poor, very poor?

Noel: Yes, Excellent. The kids' faces will tell you: they loved it…it was excellent.

Nilly: I handed a lot of worksheets and we did some experiments. What do you think about them? What do you think about the activities, the handouts, and the experiments of this year?

Noel: They (the learners) find it very enjoyable. You know that worksheets bring to mind work, and you'll see from the video's: the kids really got involved … The signs that followed a worksheet showed it very clearly when dealing with ADHD children, that they were very well focused on the activity and got involved with the worksheet. It was a very interesting piece of paper, if you wish, that was lying in front of them…

Nilly: Was it too difficult? Too easy?

Noel: No, I think it was at the level for most of them. You pitched at the level it was meant to be. One or two had difficulties...

Nilly: And the experiments that we did this year as compared to last year? We had experiments on solutions. This year we did some experiments around solids, liquids, gases, what do you think about that?

Noel: I think that on both occasions the experiments were very well presented and on both occasions the kids really enjoyed it getting involved. The only different this year is that they are still younger and they were a little more enthusiastic about it, and for me from the behaviour perspective, you know, they got all maybe too involved if you wish, whereas the older group knew what level they could take it to. On both occasions the kids loved it, and I think they learned from it. Absolutely it was enjoyable- yes there is no doubt about it.
Even learners like **Tk**, who have very short attention span, would ask for more

Nilly: Where there enough experiments?

Noel: No, not nearly... I'm speaking on behalf of the children, if they could they would do experiments every single day...
But if you were asking me if there were enough experiments to cover the material I would say, yes.
You did the two couple so well you will get the chance to do more. I don't know. Purely from the children perspective they would love it.

Nilly: I have increased the usage of pages (exercises) from IE different instruments. Did it contribute to their (the learners) understanding of the skills?

Noel: Nilly, I think one of the reasons we had this kind of success in transfer from one discipline to another might have to do with the fact that there were more pages and use. I can't say for sure, but I think so.

Nilly: it consolidate the basic skills and their understanding and we bridged it.

Noel: Yes

Nilly: Was it sufficient or would you use it even more?

Noel: Well, they coped, they coped adequately, and we just ran out of time. I think and if you could use more I can't see why it would not benefit them. On the same talking, having you increased it this year compare to last year, if you would do it the same for next year- would the benefit be as much as last year? I think so, yes, even more.

Nilly: using it more means less time for bridging it to science. This balance between science and basic skills and IE?

Noel: I'll be continuing with science next term so they will have more science this year where as before they had one history, one geography, one science.
We will continue with it within the framework, as it was presented this term. We will be doing 'reproduction' of animals in mammal's world next term, and our only problem is that we need good balance between thinking skills and learning of new content. We had only so many weeks to do it. I think that if we had six months of period we would be able to apply more of the instruments and cover the same amount of material we covered in three months, over the six months period. What else can I present in your absent and take it down the line for the children?

Nilly: or even use the same skills that were taught but consolidate them- let them use it more...

Nilly: How was the bridging from the instruments to the science topics in your opinion?

Excellent, good, fair, poor, very poor?

I handed a lot of worksheets and we did some experiments. What do you think about them?

Noel: Good, good

Nilly: Was it better than last year?

Noel: Excellent. In the beginning we spoke about it as a goal you set after some feedback from my side. I think the improvement was definitely much better than last year. You were constantly aware of the bridging.

Nilly: Did the programme contribute to their attitude towards science as a subject matter? To what extent?

Noel: Good. If they knew that Nilly is coming back to teach science they would definitely go for it. As a follow up exercise in COGNET I asked 'in what way what you learned in Nilly's science class will help you to think about becoming a scientist'. Maybe the question was a little too difficult for them for the most part they said: they enjoyed the class. They did not quit understood the full meaning of my question… they said they would listen to something like that, that they would get back to a science lesson next year whether it was you or me…
If I would say it is the way Nilly does it- they would remmember the experiments that you did...

Nilly: We discussed and reflected the lesson every time approximately throughout the term. Could you see, feel, any outcome from those discussions? Did the reflections caused any change?

Noel: Definitely, because if we look at using the co-operative teaching. The groups work, we spoke several times about the group work. You were able to mediate through getting the groups to discuss as one mediate one on one base, as one on group base, and come back and report to the rest of the class.

Nilly: can you describe me again as a teacher as opposed to last year?

Noel: well, we can't compare but...
Let me think... last year...
You were a lot more enthusiastic. Not that you were not enthusiastic there, but because you put a lot more expressions into your teaching, you were more comfortable with the language aspect, you certainly had.
You did not need me for the control aspect... I think...
Am...but generally speaking, you were better at it this year than last year. I think partly because we had the experience of last year to base a standard teaching. You gave more from yourself.

Nilly: How was the level of creativity? Excellent, good, fair, poor, very poor?

Noel: Level of creativity? Much better than last year. The material you prepared was far more creative than last year. I will rank it *'good'*.

Nilly: How was the level of flexibility? Excellent, good, fair, poor, very poor?

Noel: Very flexible. Just thinking about the way you moved from group to group, individual to individual, stopping, listening, because the kids want to give from themselves a lot... I will rank it *'Excellent'*.
it has to be seen in their need to know if I'm coming again today, or tomorrow or the day afterwards. Another example is ' Nilly is not coming on Friday' and the discussion was "Nilly"
Compare to the other substitute we both know...

Nilly: How was the level of listening to children's problems?

Noel: Nilly, I think it was excellent. Sometimes giving one learner too much of that at the expense of one or two other individuals or groups.

Nilly: At last: how was the programme organised and facilitated?

Noel: I can only say: excellent.
If we look at Dr Worral and R. (principle of the school) comments on the last year material they thought it was amazing. So it is not just my opinion.

Nilly: Would you recommend any changes to this programme?

Noel: Changes to the programme? Not to the programme it self. When I look at the approach to it, what benefit the children and you and I better... If I and you had a discussion about the forth coming lesson before it was dealt with, just to say: 'when you ask this question throw it to the group- not to the individual' - that sort if things.

Nilly: do you mean planning together?

Noel: Yes, yes. Not a change to the programme, but when you set up the plan for a specific lesson we go throw it together and we look at areas that, may be on the previous two occasions there was not sufficient group anticipation so we can bring it up...
So to get the most out of the groups...

Nilly: I'm coming back to the mediating, cause it was one of my goals...

Noel: Compare it to last year, there is a significant difference in my opinion. I have no doubts in my mind that the mediation in general and across the 16-17 lessons done was a great improvement of the last year. And that when we had our feedback sessions after the lessons- the few little improvements that we wanted to make would be carried forward into the following lessons.
So over all I think it was a very big improvement in my opinion from last year.

Nilly: Do I use all the opportunities or most of the opportunities I can? To ask for justifications? To bridge 'Meaning'? Those type of things?

Noel: Mostly, absolutely mostly.

Nilly: did the kids enjoy it?

Noel: Oh, what can I say?

Nilly: Thank you very much Noel. Anything else you would like to mention?

Noel: I enjoyed our time together with the children...(reads from the white board behind him): "We love you very much, we are going to miss you very much..."

What more I can say, from my side and from the children side it was very successful and much better than last year. They loved the experiments and you as a person. They say it on the board...

The End.

Appendix G

Cel

שיעור מס' 3: השתתפות טובה. היה מענין. [illegible] — שיעור מס' 2: לדעתי קלין מבין מהם סימני החיים (נותן דוגמאות) [illegible] (לפי הקטגוריות לחוץ, צורה וגודל) [illegible] differ, [illegible] Organism [illegible]

[illegible] sign [illegible]

[illegible] bush [illegible]

[illegible] שיעור מס' 14: אני [illegible] מהשתתפות שלו. הוא [illegible].

[illegible] R [illegible] שיעור מס' 8: [illegible]

[illegible] R [illegible]

[illegible] שיעור מס' 11: [illegible]

[illegible] שיעור מס' 7: [illegible]

[illegible] 2 [illegible] Bat [illegible] Chip-[illegible] [illegible]

[illegible] Hectic! [illegible]

[illegible] שיעור מס' 6: [illegible] (1-2 [illegible]) 6 [illegible]

[illegible] Skill [illegible]

[illegible]

שיעור מס' 12: [illegible] classification.

Col

Lesson 1: OOD [illegible] Lesson 3 following instructions:

[illegible] 2 [illegible] 4 [illegible]

[illegible]

[illegible]

[illegible] Vodka [illegible]

[illegible]

Lesson 2 SysAppe [illegible]

[illegible] Lesson 4 Measurement: [illegible]

[illegible]

[illegible] blood sugar levels [illegible] cloning [illegible]

[illegible] (Solids) [illegible]

[illegible] Noel [illegible] 1 [illegible] 2 [illegible]

שלב 1: [illegible]

שלב 2: [illegible]

שלב 3: [illegible]!!

Col

[illegible] מה היא מצפה - "מה את רוצה" [illegible] שיעור מס' 2: [illegible] עם את [illegible] מציירת

אבסטרקטי - לקחת [illegible] ולקנות [illegible] ... את המטרה [illegible] את האבסטרקט - קצת [illegible] אין לא משלים את

[illegible] ... [illegible] חומר הקנה כמו [illegible] חומר [illegible].

זה הוא [illegible] סימן שסטרס הולך (אומר נכון) שלא [illegible]. אין דבר. אני בטוחה שיודע את הדברים האלה.

[illegible] ... [illegible]

[illegible] ... Venn D [illegible]

[illegible] inffer [illegible]:

"When you inffer its like archeologist that look at at a skelleton and say how old it is and so..."

[illegible] ... [illegible]

[illegible] ... "[illegible]".

[illegible] (8).

He wanted to know how you say Kaved...

[illegible] Skeleton and [illegible] metaphoric...

[illegible]

[illegible]!

feed the fish... [illegible]

[illegible]

[illegible] Col ⇐ IE COMP [illegible] leaves, black hair,

[illegible] 2 : [illegible] I [illegible] II [illegible] III [illegible]

IV [illegible] V [illegible] VI [illegible] 4/6 [illegible] dark [illegible] lite ...

[illegible] No/doors&windows [illegible]

[illegible] ⇐ 3 [illegible] Salute [illegible] (!)...

[illegible] 3 Venn [illegible]

[illegible] 7 : [illegible]

[illegible] Tea [illegible]

[illegible] 3 [illegible]

[illegible] 3 [illegible] 5 [illegible]

[illegible] that [illegible]

[illegible] (8) [illegible] Dimention [illegible] I [illegible]

[illegible] limbs [illegible] Walk [illegible]

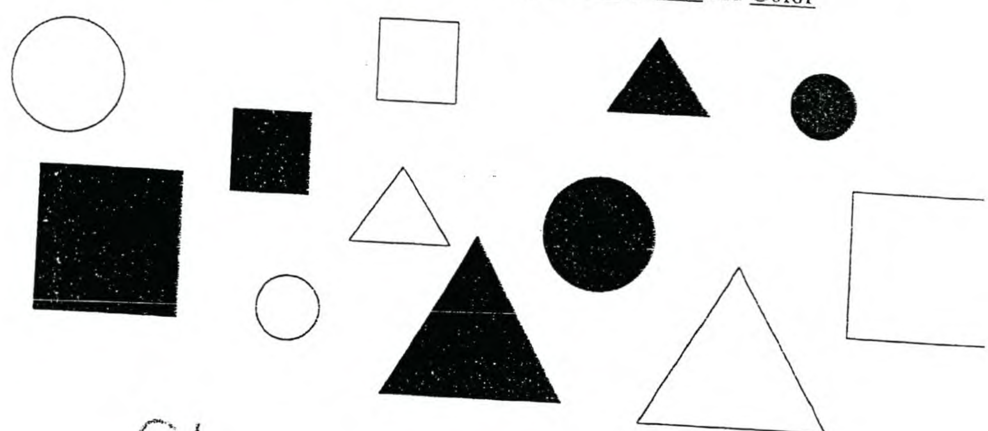
[illegible] Col [illegible]

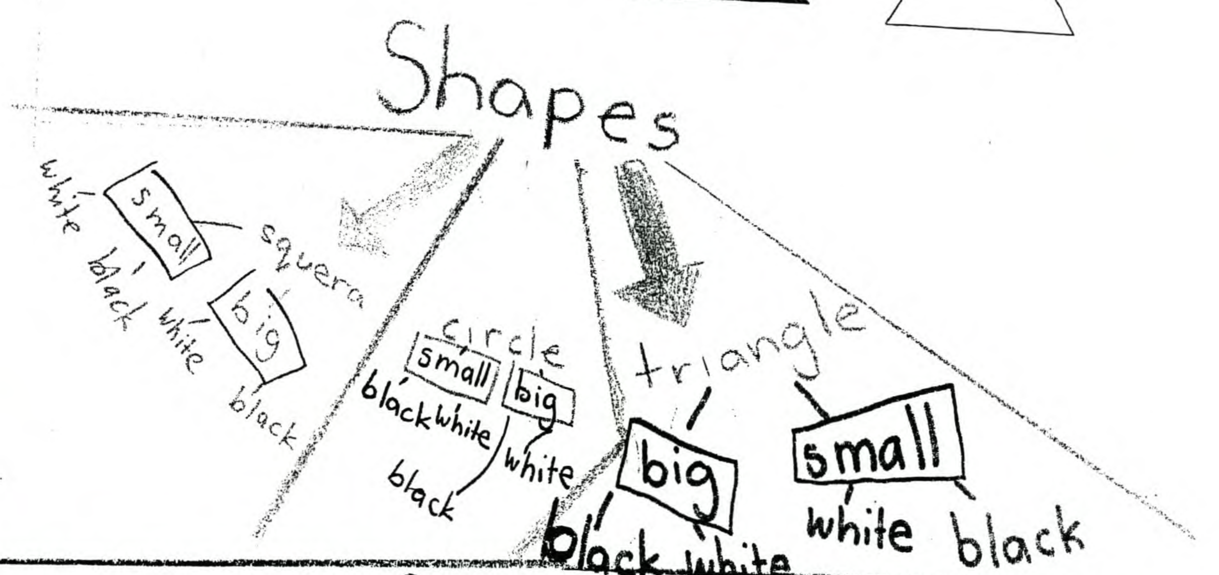
[illegible] (...)

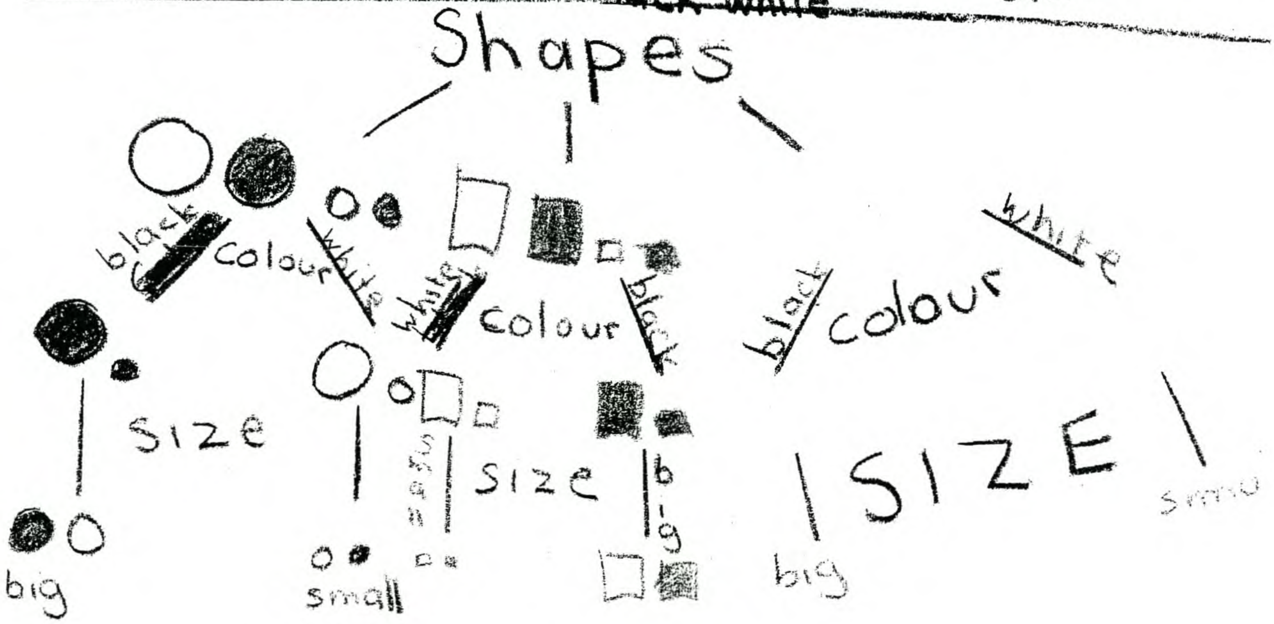
Appendix H

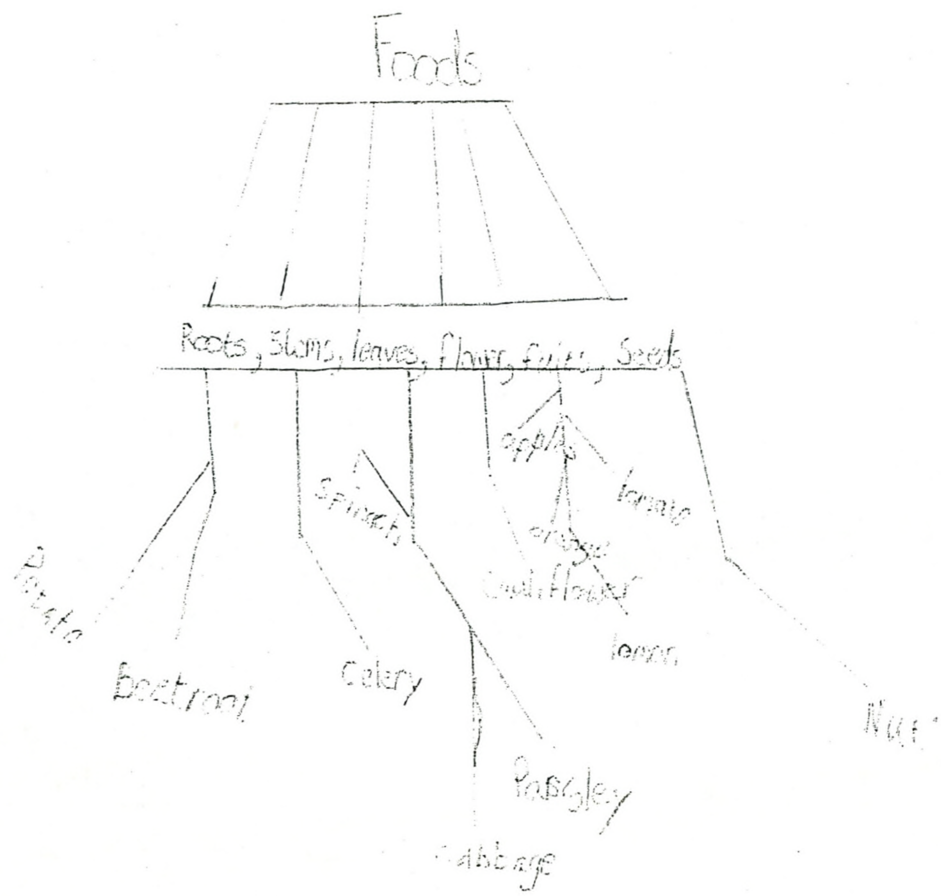
classshape K

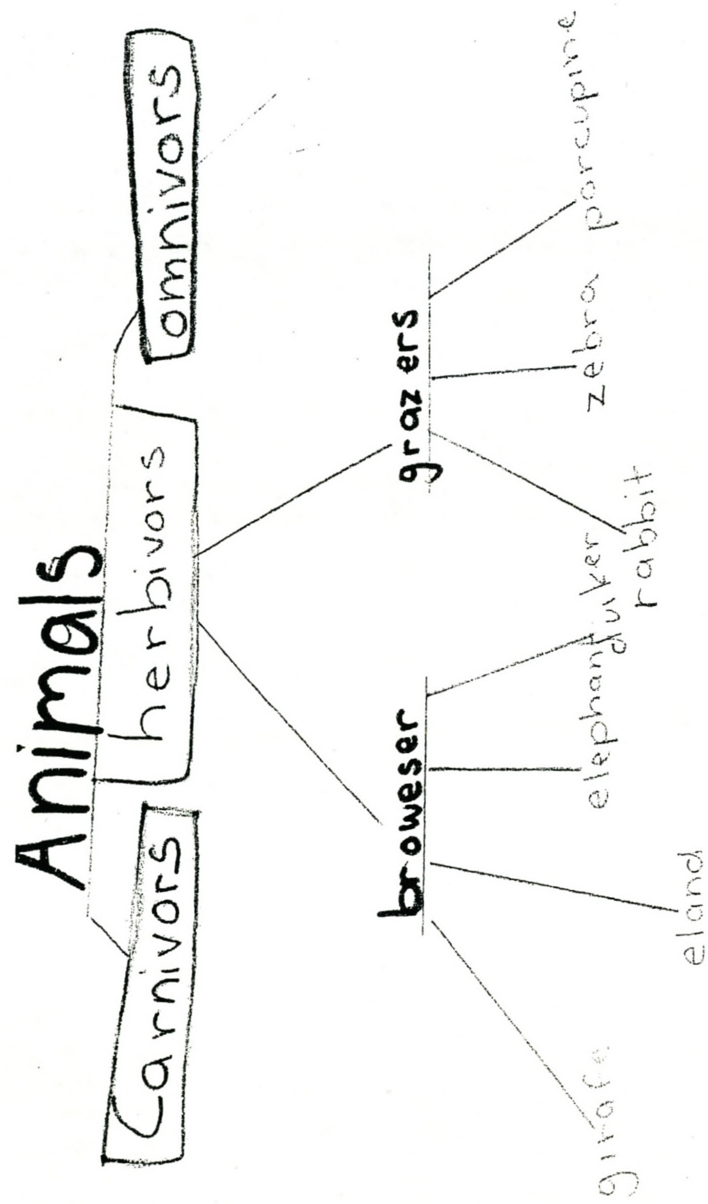
Please **Classify** the geometric forms according to **Size**, **Form** and **Color**

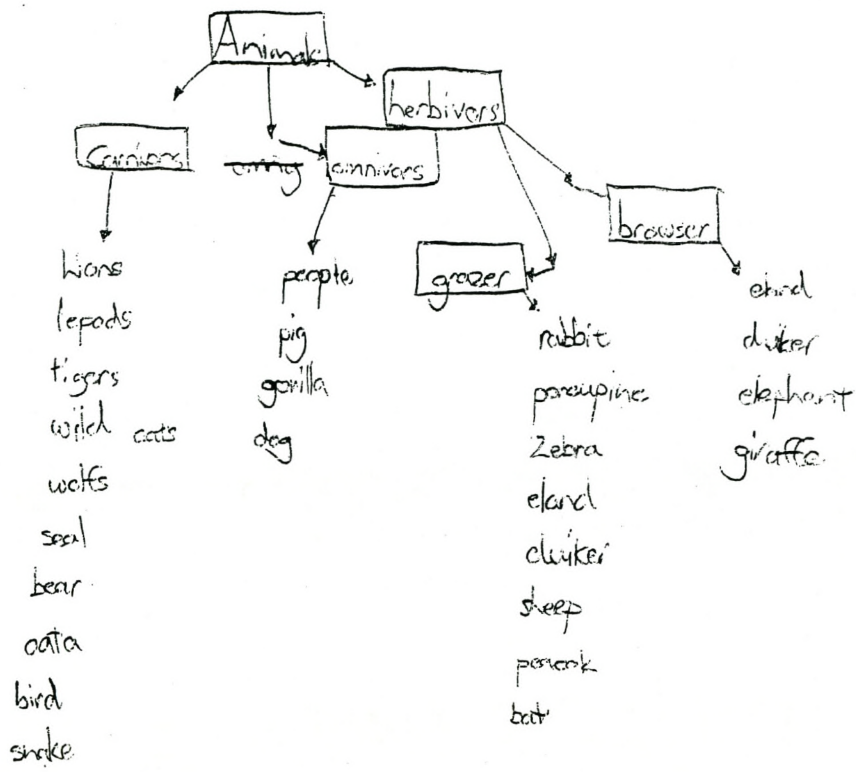


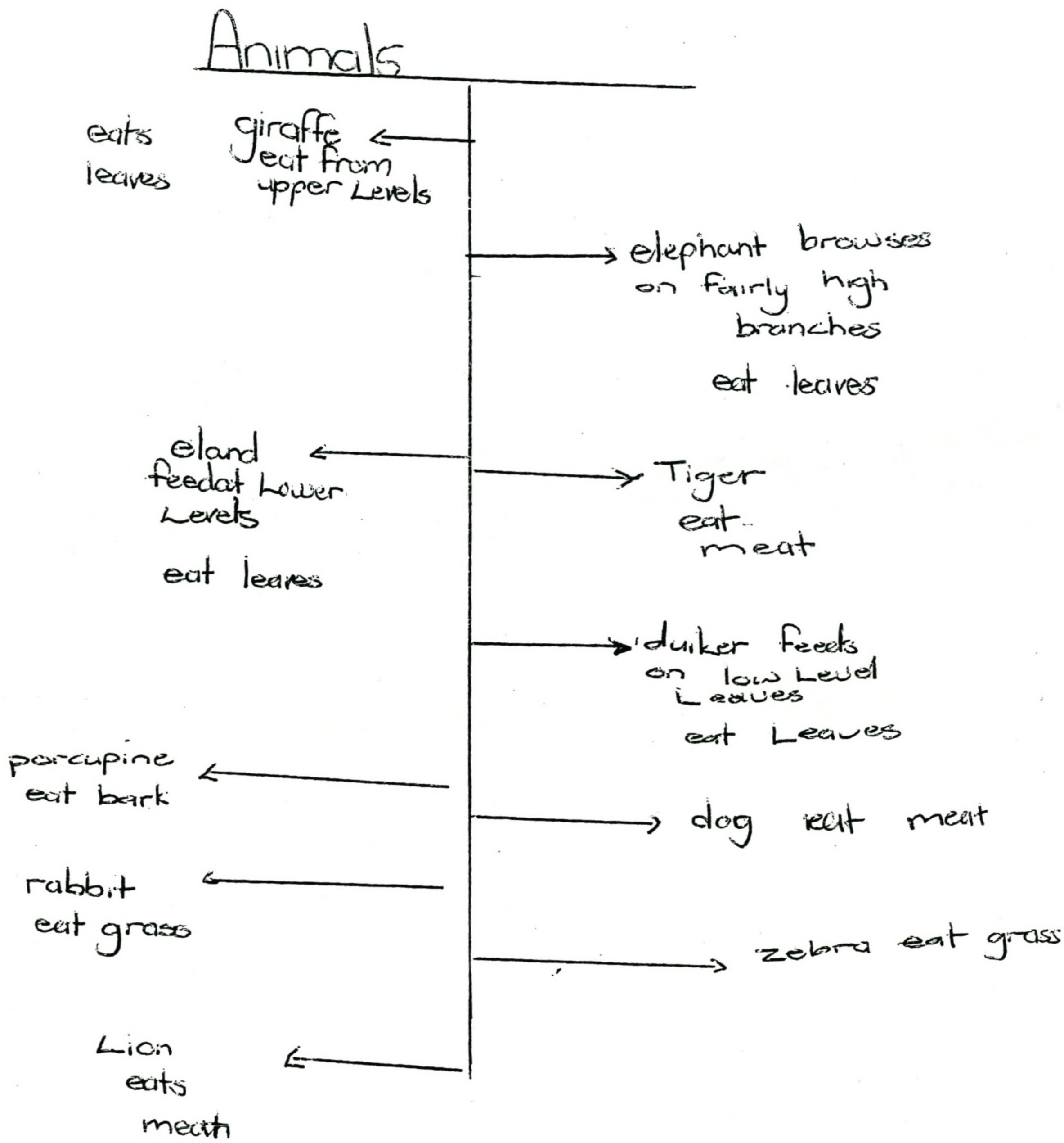





Foods
Roots, Stems, leaves, flwrs, fruits, Seeds
Potato
Beetroot
Celery
Spinach
Cabbage
Parsley
apple
orange
tomato
lemon
Cauliflower
Nuts


Animals
Carnivors
herbivors
omnivors
broweser
grazers
giraffe
eland
elephant
duiker
rabbit
zebra
porcupine


Animals
Carnivors
omnivors
herbivers
browser
grazer
Lions
lepods
tigers
wild cats
wolfs
seal
bear
bird
snake
people
pig
gorilla
dog
rabbit
porcupine
Zebra
eland
duiker
sheep
peacock
bat
eland
duiker
elephant
giraffe


Animals
eats leaves
giraffe eat from upper Levels
elephant browses on fairly high branches
eat leaves
eland feedat Lower Levels
eat leaves
Tiger eat meat
duiker feeds on low Level Leaves
eat Leaves
porcupine eat bark
dog eat meat
rabbit eat grass
zebra eat grass
Lion eats meath

food to eat

fruit: Lemon, Orange, apples

leaves: Cabbage, Spinach, Cauliflower

stems: Celery, parsley, ~~Be~~ Beetroot

flower: Tomato, potato

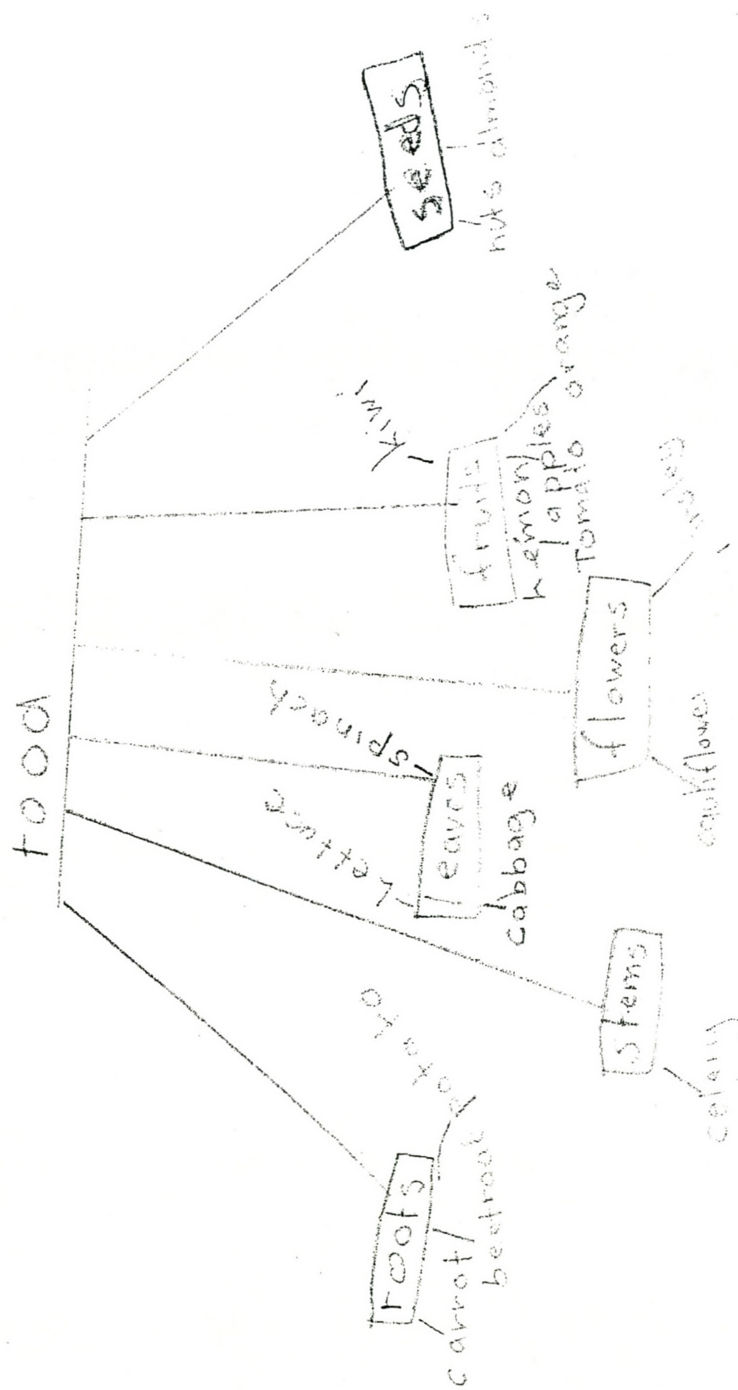
seeds: nuts

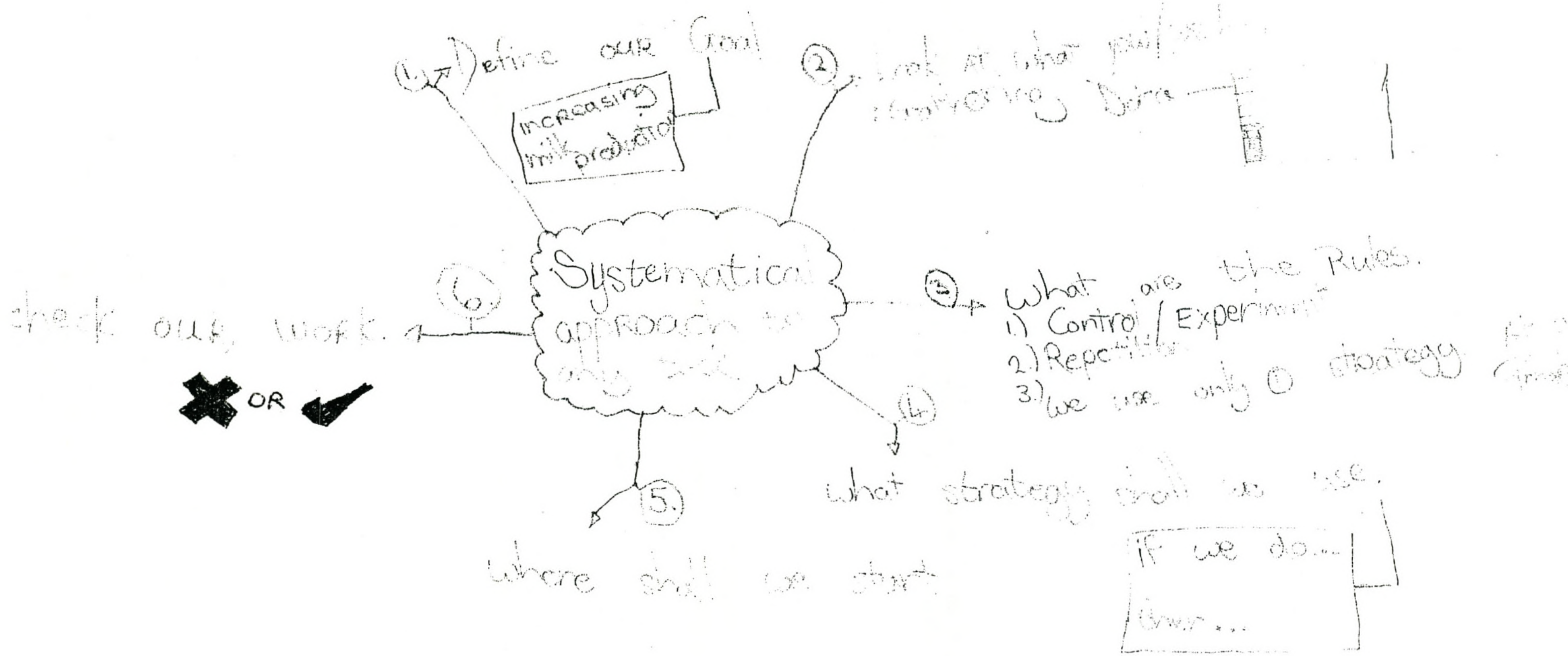
~~leaves~~ leaves and ~~gr~~ grass and trees.

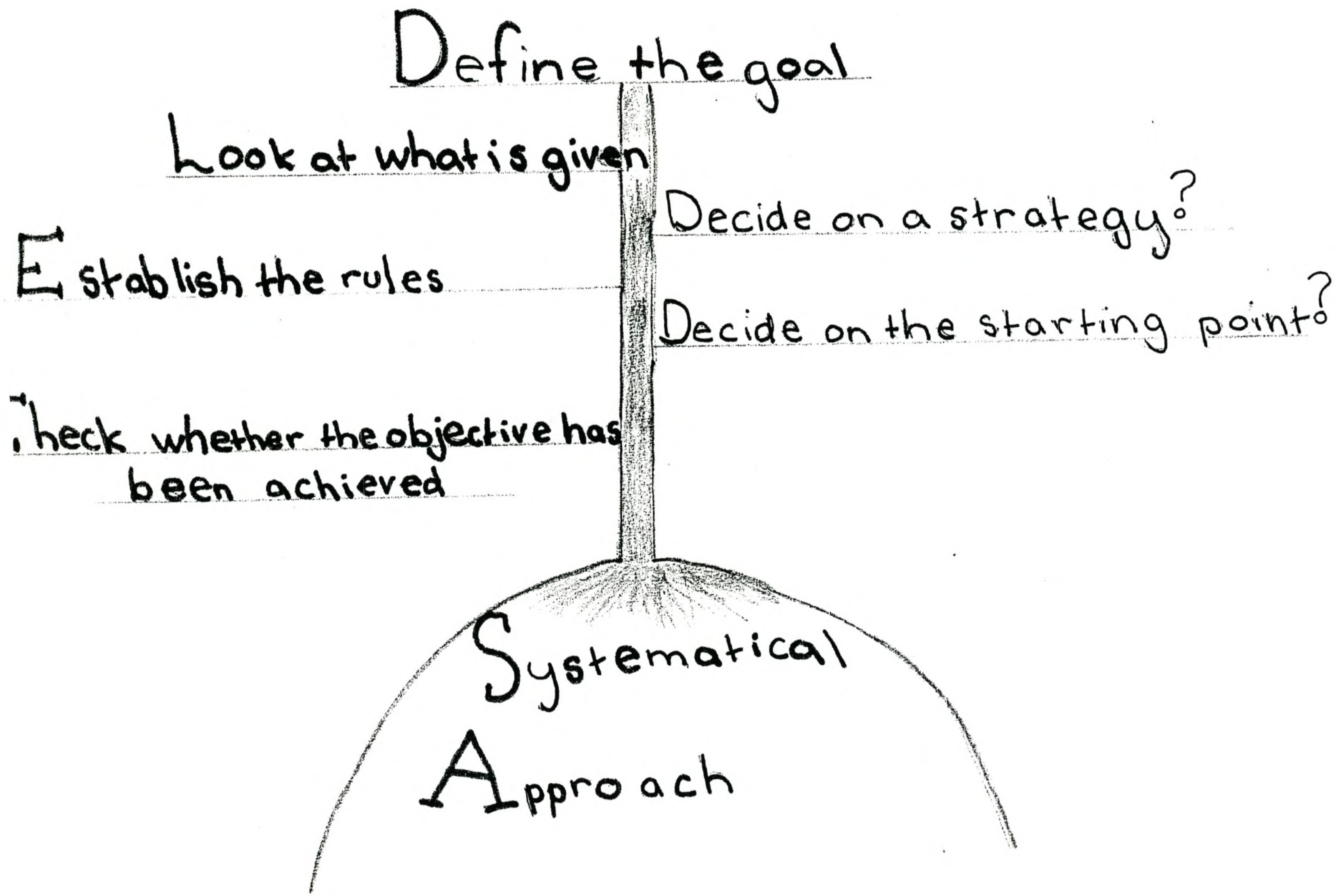
Zebra eats grass

porcupine eats bark

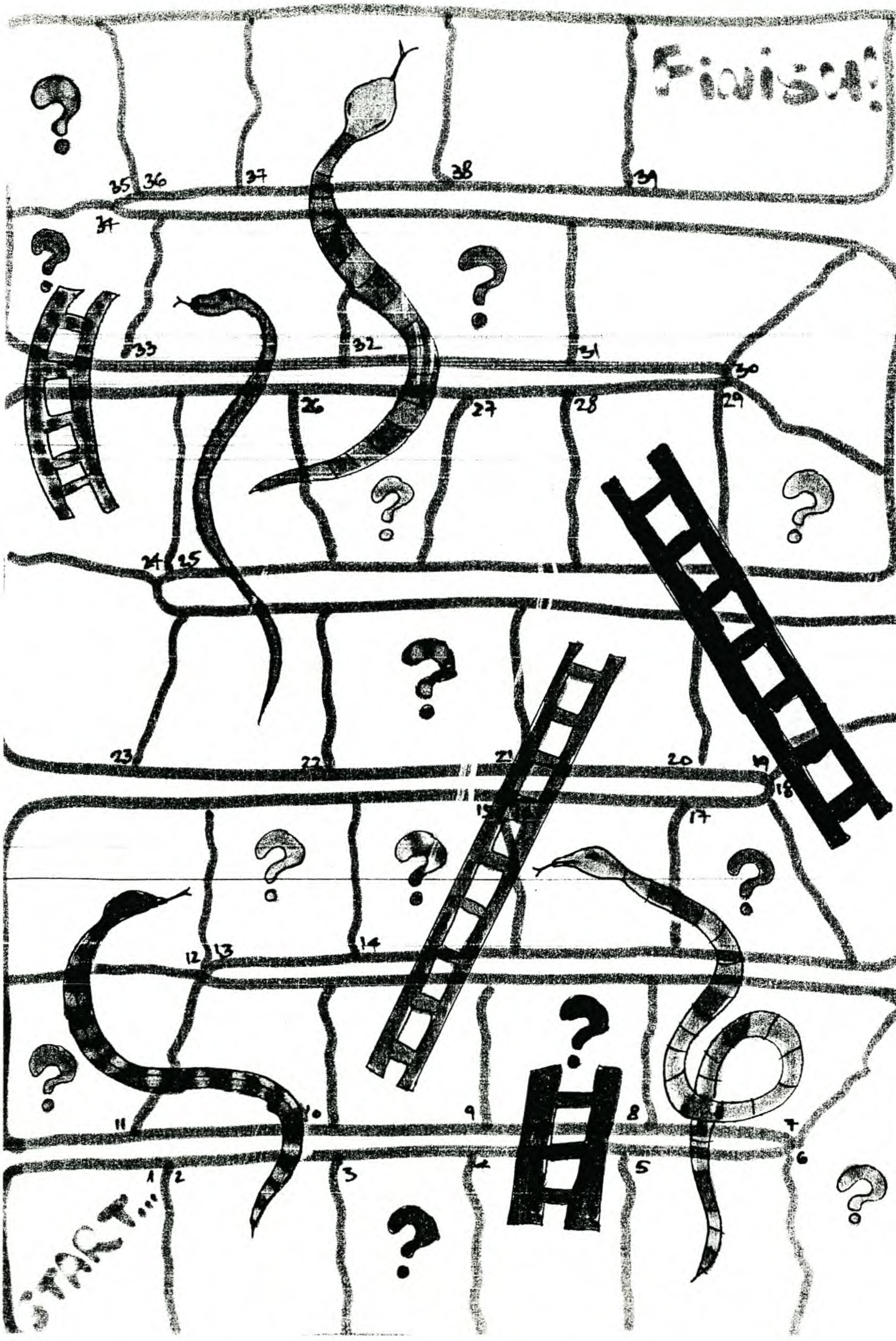
I do not no.


food
roots
carrot
beetroot
potato
stems
celery
leaves
lettuce
cabbage
spinach
flowers
cauliflower
lemons
apples
Tomato
orange
kiwi
seeds
nuts almonds


Systematical approach to
Define our Goal
increasing milk production
Look at what
What are the Rules.
1) Control / Experiment
2) Repetition
3) we use only 1 strategy
What strategy shall we use.
If we do...
Where shall we start
check our work.
OR


Define the goal
Look at what is given
Decide on a strategy?
Establish the rules
Decide on the starting point?
Check whether the objective has been achieved
Systematical
Approach

Appendix I

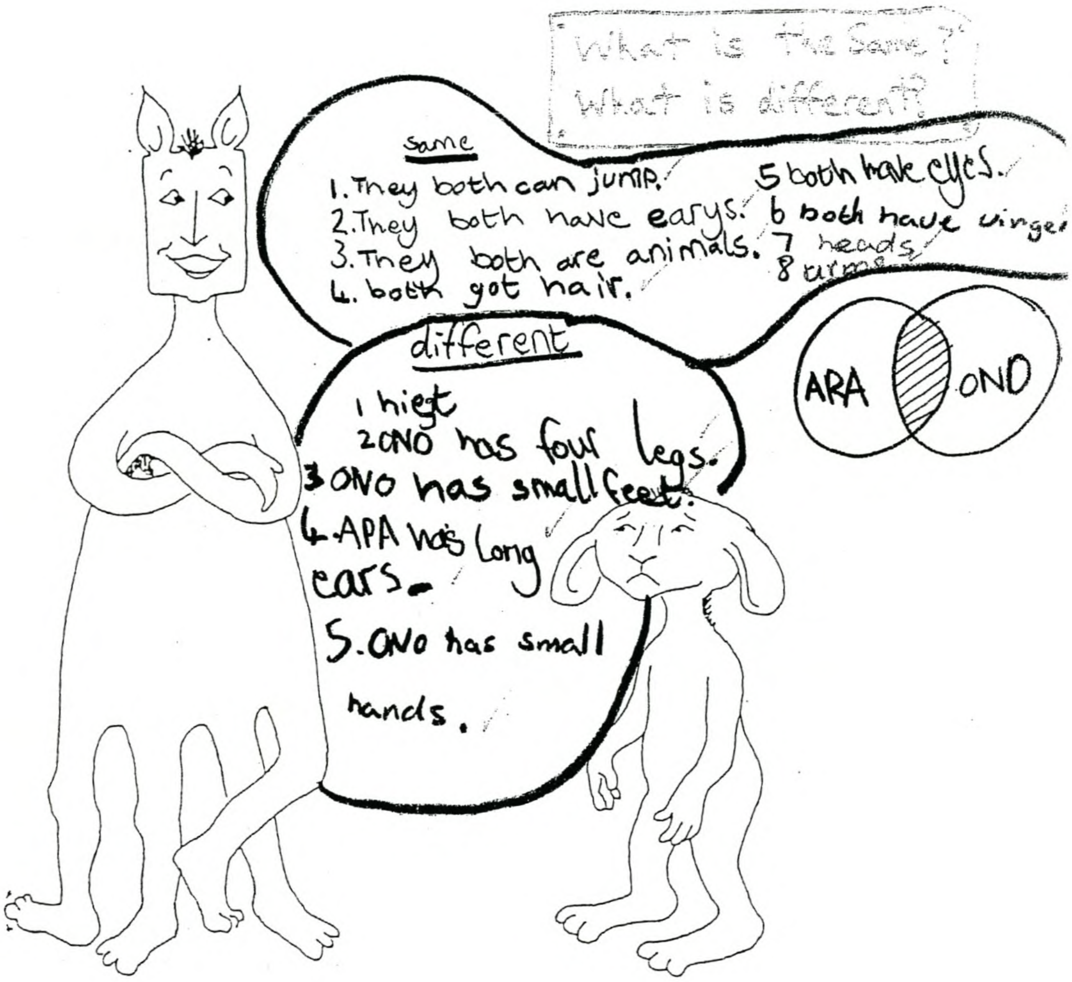

Finish!
START...
1
2
3
5
6
7
8
9
10
11
12
13
14
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39

True or False? Matter is made of small particles.	True or False? In liquid the particles can hardly move.	True or False? In liquid the particles move around freely.	True or False? In Gas the particles can hardly move.
True or False? In Gas the particles move fast and spread out.	True or False? In Solid the particles can hardly move.	True or False? In Solid the particles can move freely.	True or False? All substances are liquid, solid or gas.
True or False? You can change water into solid by cooling it	True or False? You can change water into solid by heating it	True or False? You can change water into gas by cooling it	True or False? You can change water into gas by heating it
True or False? Between the particles of matter there is <u>Nothing</u>	True or False? Between the particles of matter there is <u>Something</u>	True or False? All liquids are wet and can flow.	True or False? All solids are do not change their shape.
True or False? All gases will spread out if allowed.	True or False? Liquid Nitrogen is cooled Nitrogen gas.	True or False? Lava is melted rocks.	True or False? If you heat glass it will melt...

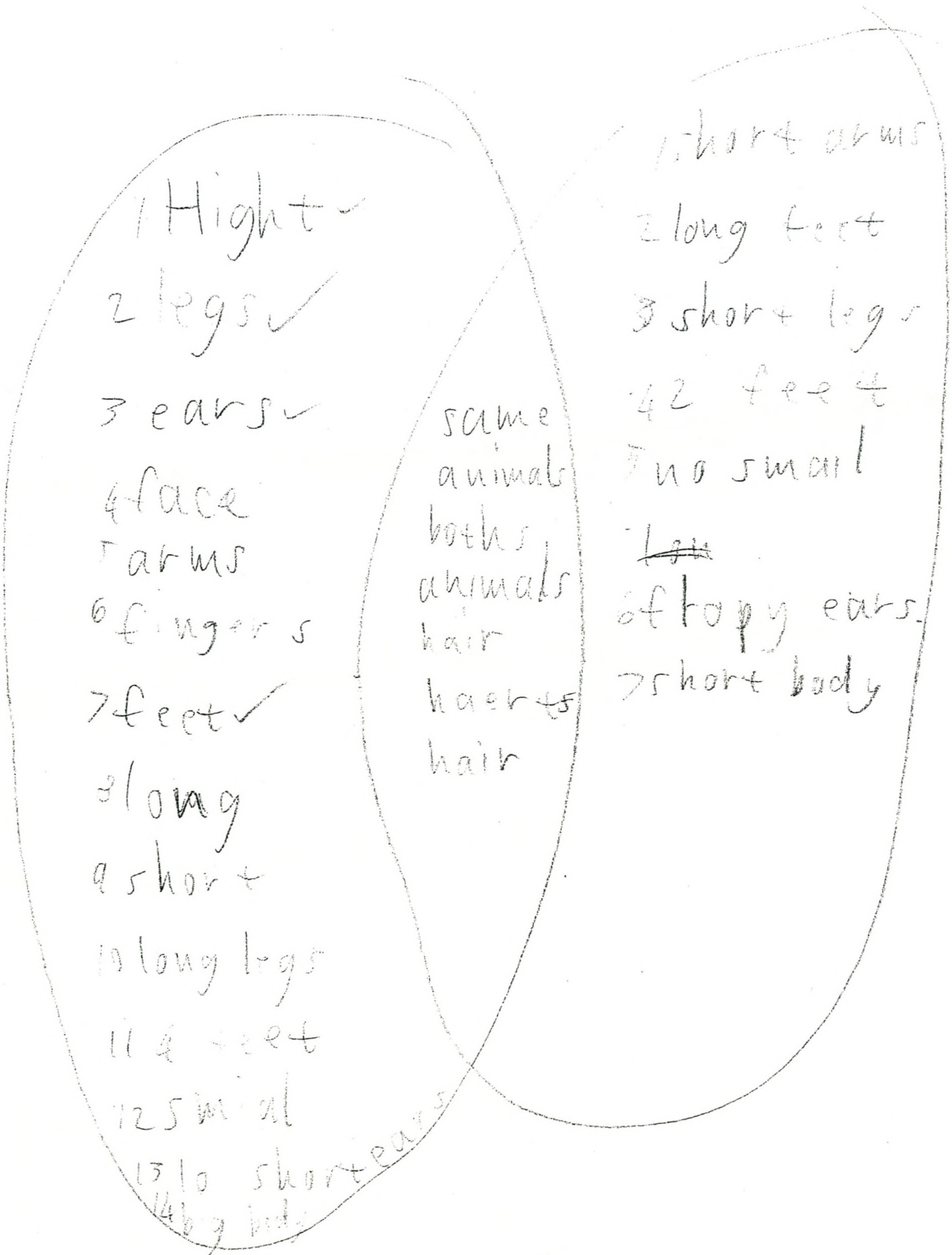
Appendix J

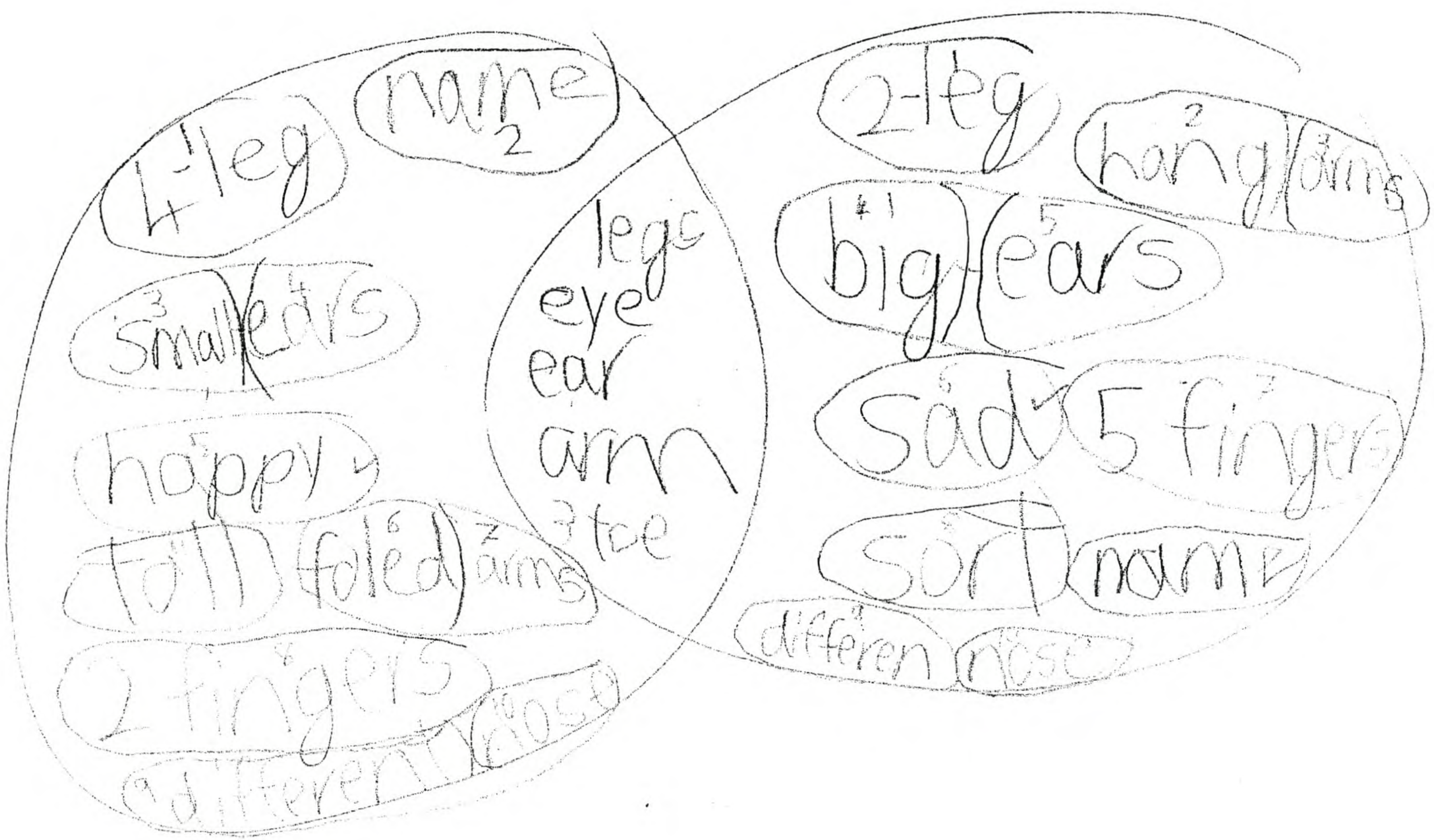
Observing Differences

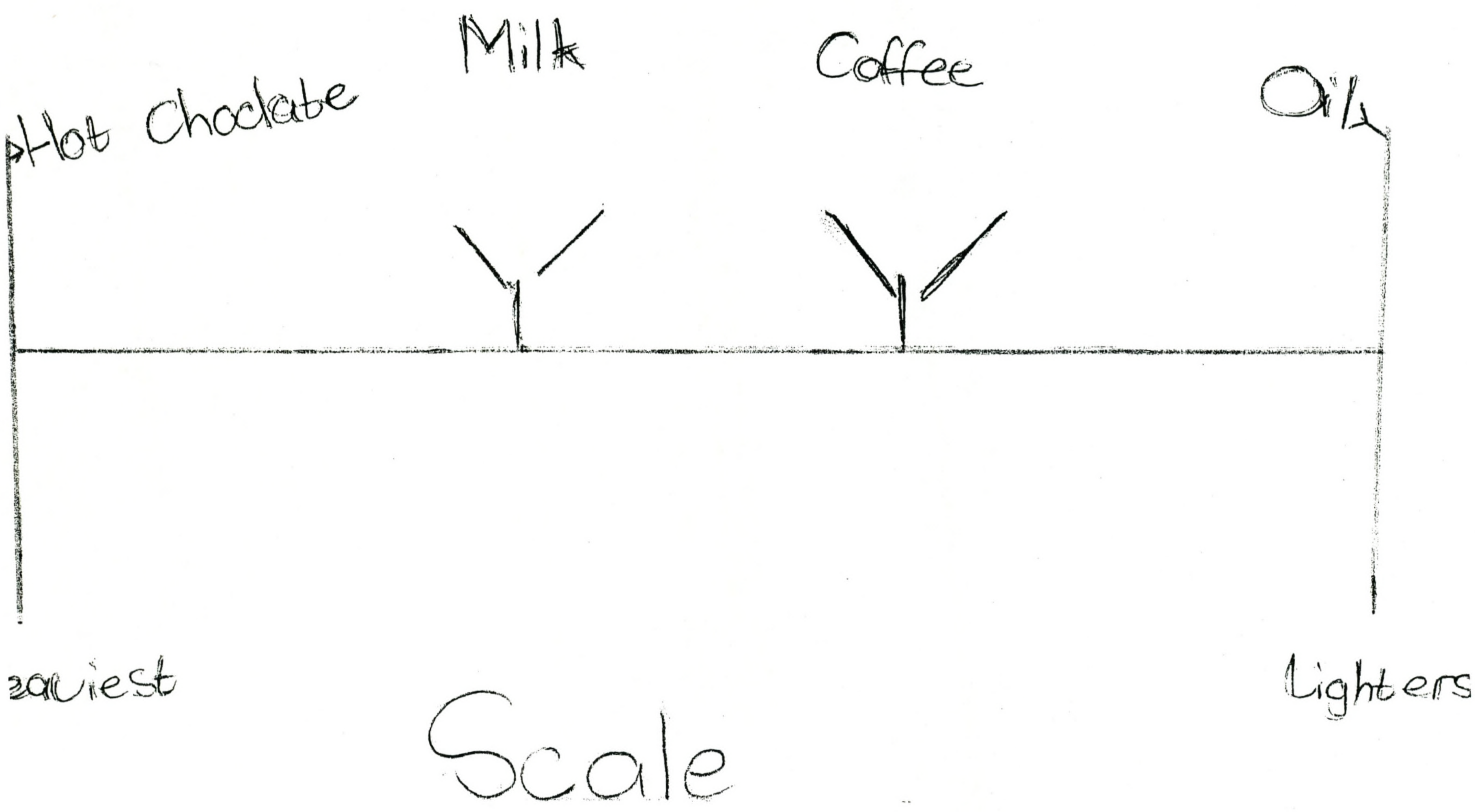
Instructions: Observe the creatures in order to identify pairs of characteristics.

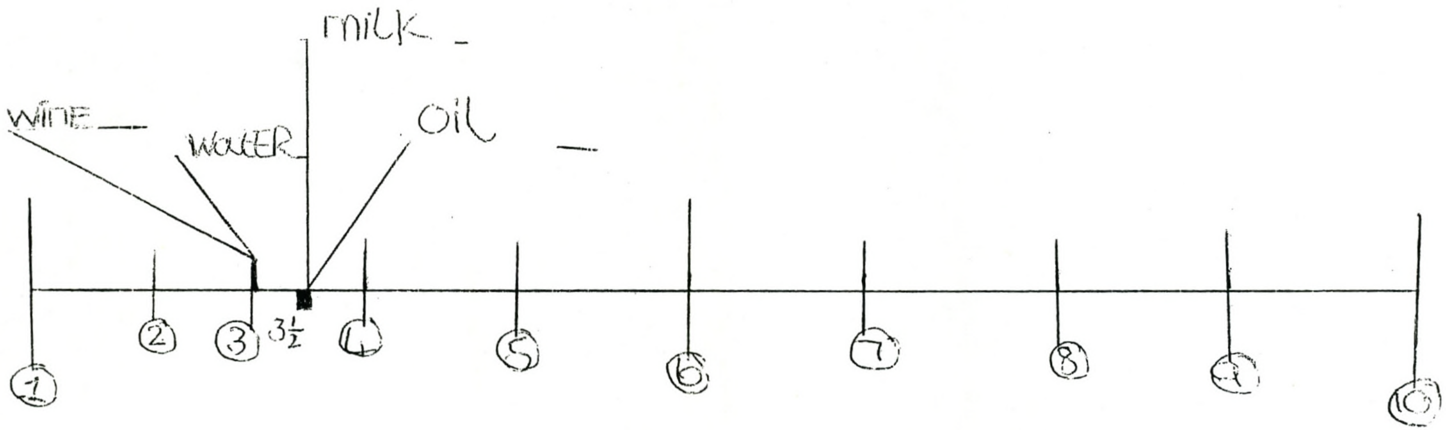


ONO **APA**

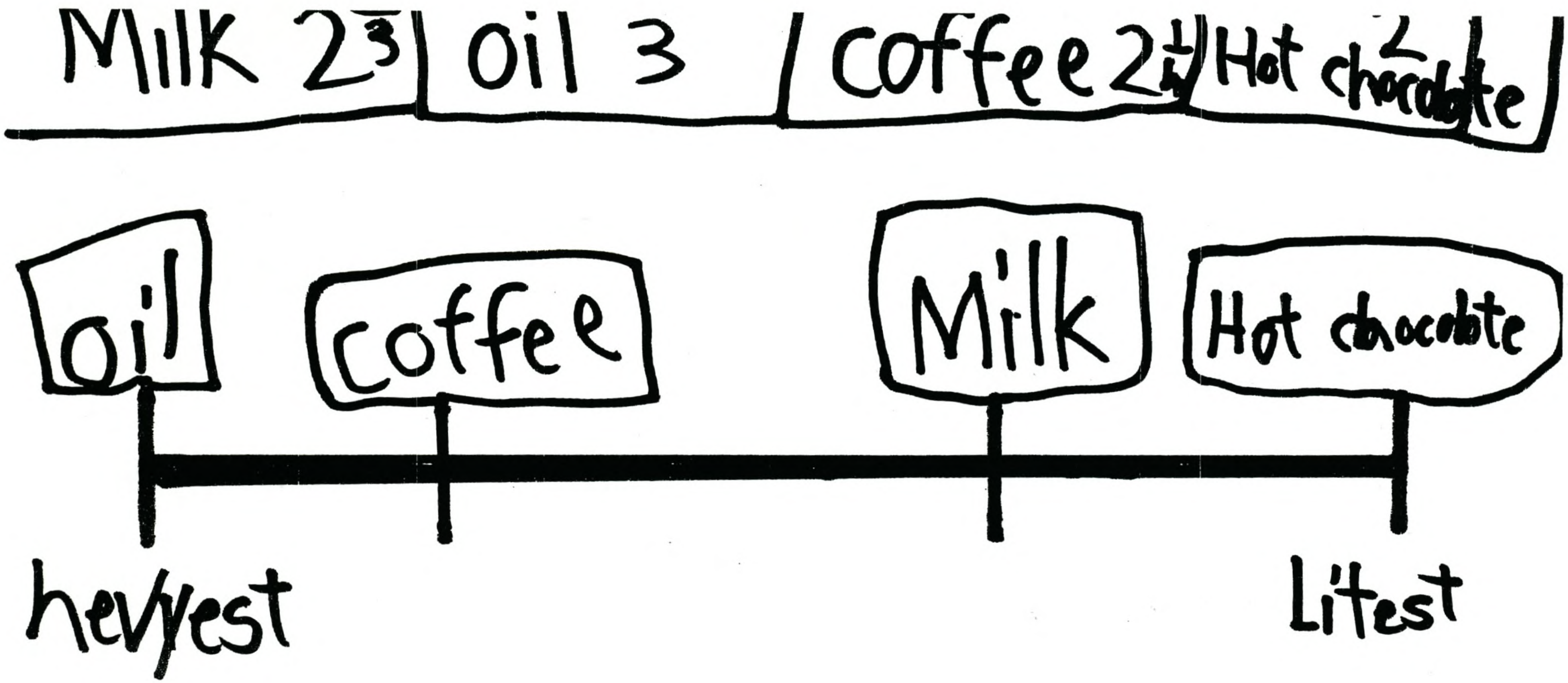

1 Hight
2 legs
3 ears
4 face
5 arms
6 fingers
7 feet
8 long
9 short
10 long legs
11 4 feet
12 smal
13 lo short ears
14 big body
same animals
boths animals
hair
haer
hair
1 short arms
2 long feet
3 short legs
4 2 feet
5 no smal
6 flopy ears
7 short body


4-leg
name
small ears
happy
tall
foled arms
2 fingers
different nose
legs
eye
ear
arm
toe
2-leg
hang arms
big ears
sad
5 fingers
sort
name
differen nose


Hot Choclate
Milk
Coffee
Oil
eaviest
Lighters
Scale



KALE RANDON AREW


Milk 2 3
oil 3
coffee 2 1/4
Hot chocolate 2
oil
coffee
Milk
Hot chocolate
hevyest
Litest

Thursday 11 September

LONG e

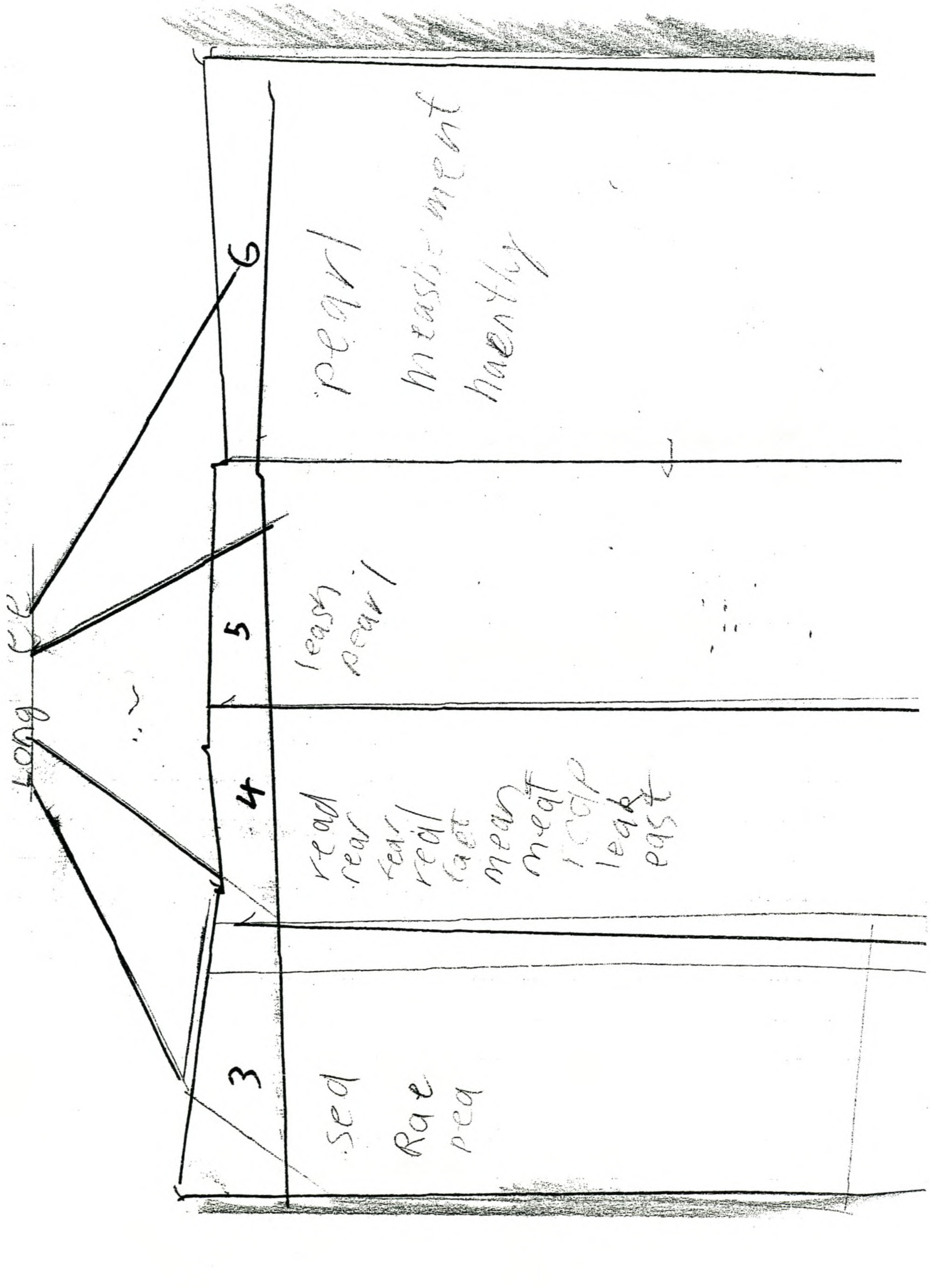
ee as in **feet**

ea as in **seat**

LONG a

ai as in **train**

a-e as in **name**

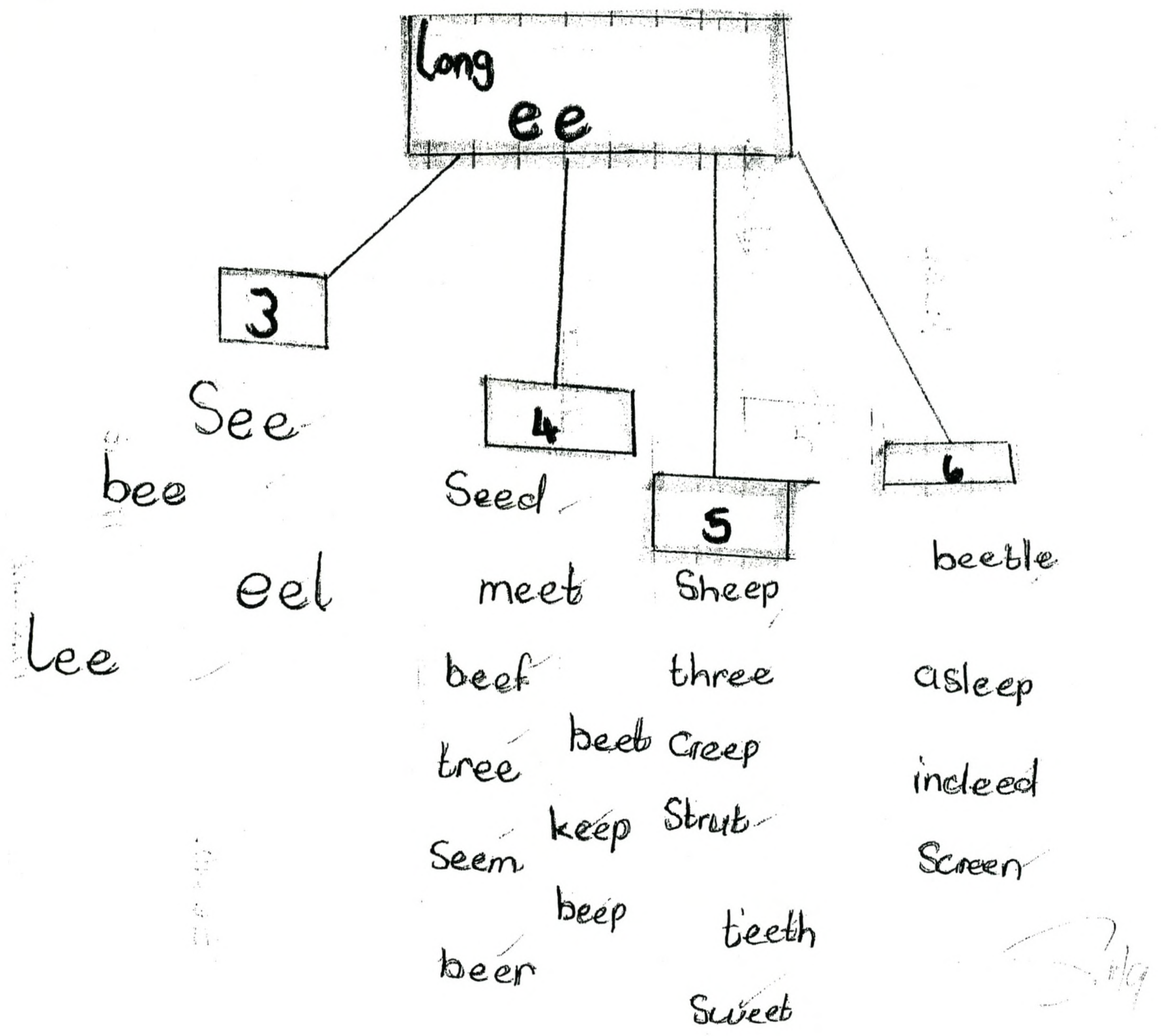


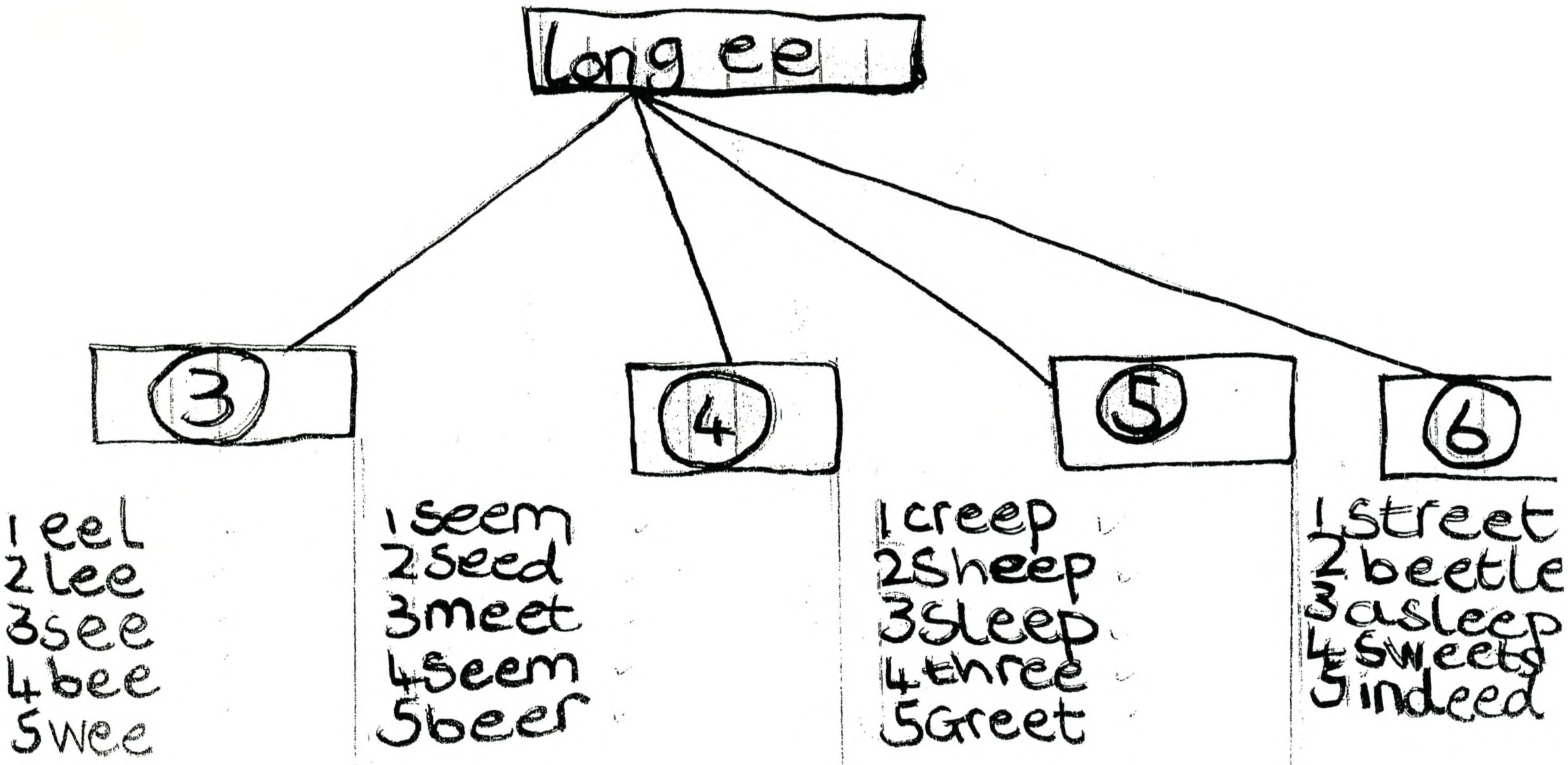
Long ee
6
pearl
measurement
5
least
pearl
4
read
rear
fear
real
meat
meat
leat
east
3
sed
Rat
pea

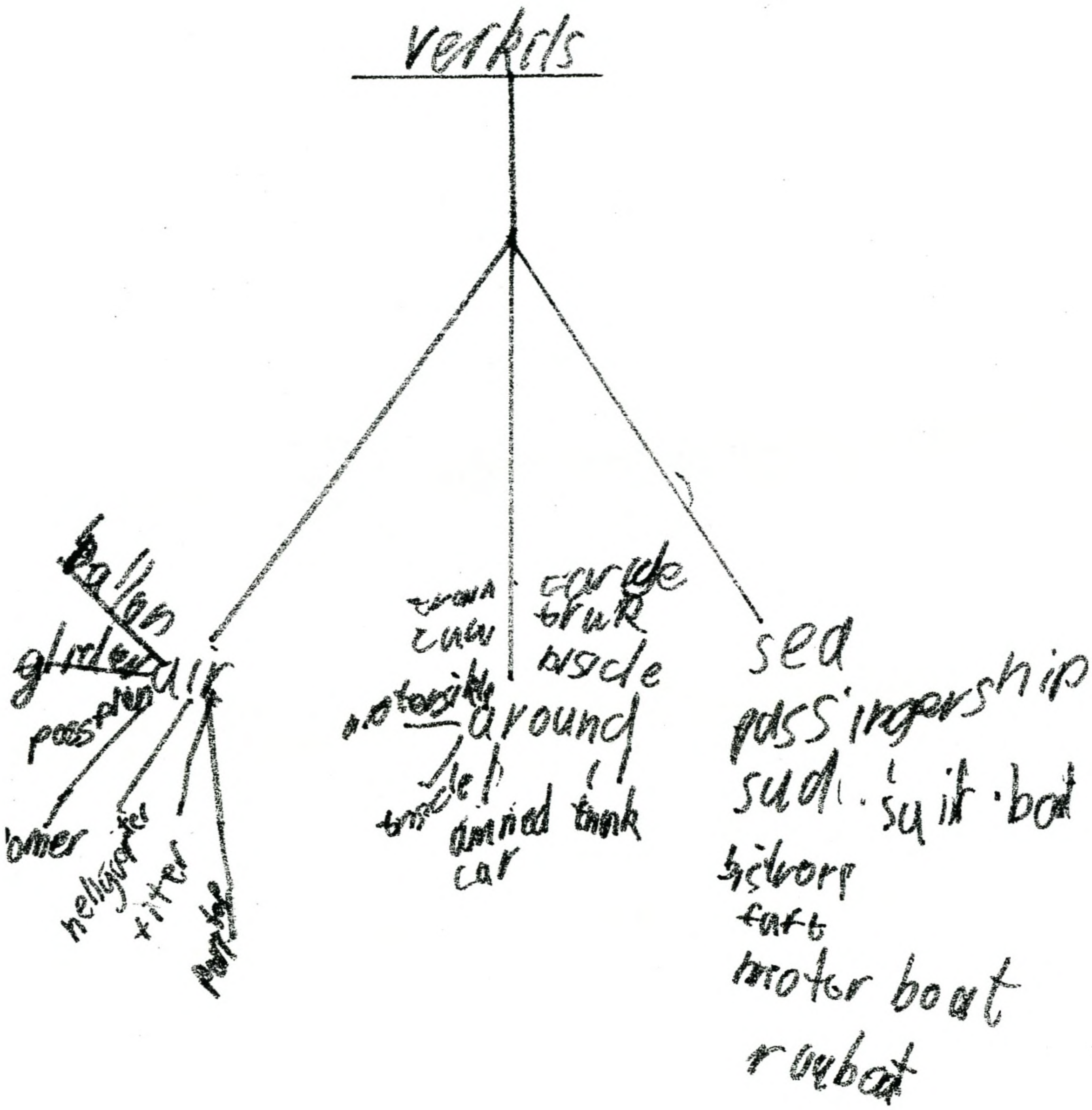
Long 'e'

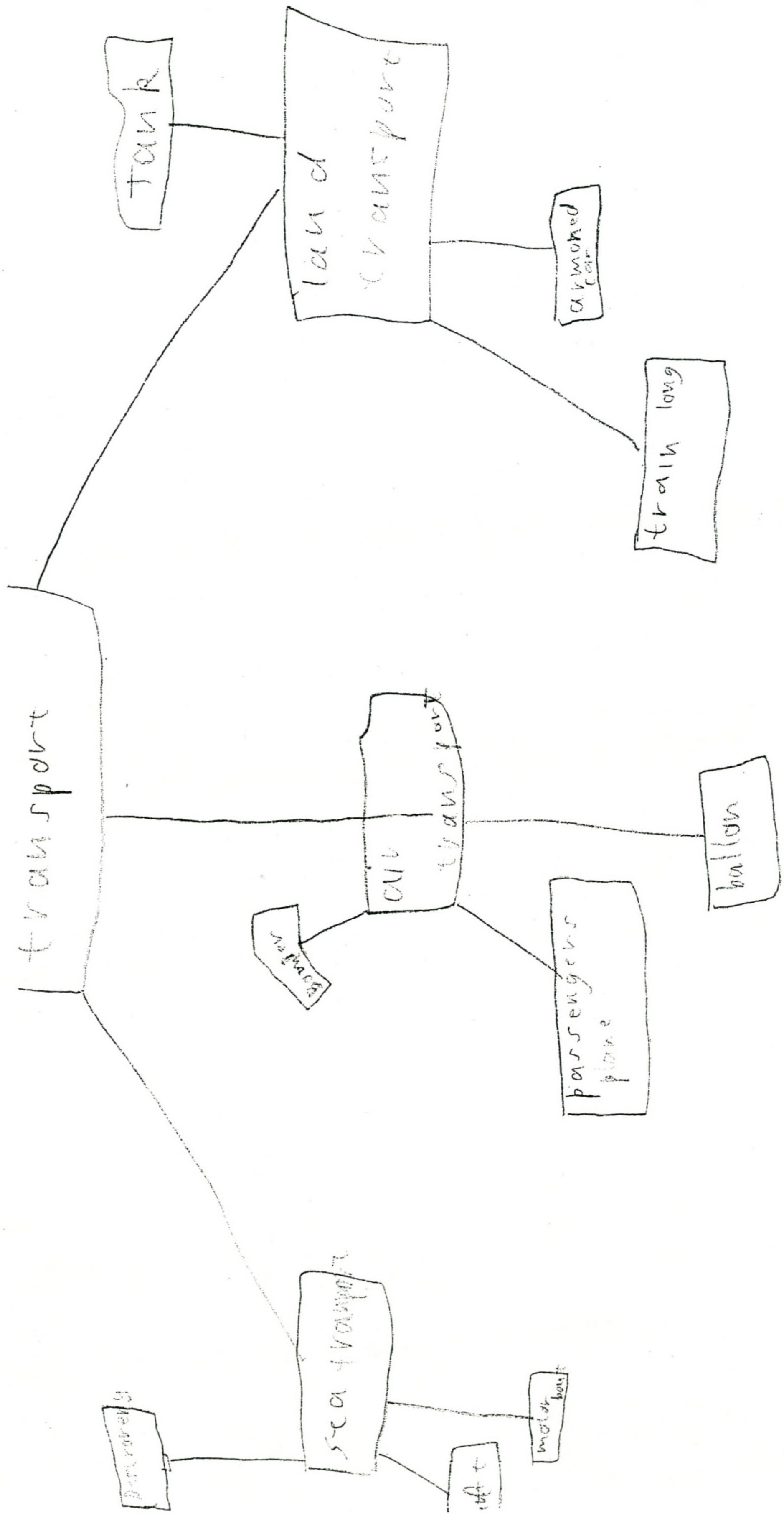
3 letters in the word	4 letters in the word	5 letters in the word	6 letters in the word
see	meet	creep	street
bee	seem	sheep	asleep
wee	beer	sleep	beetle
	seed	green	cheese
	keep	three	
	tree	queen	
	beet		
	beep		
	beef		
	weed		

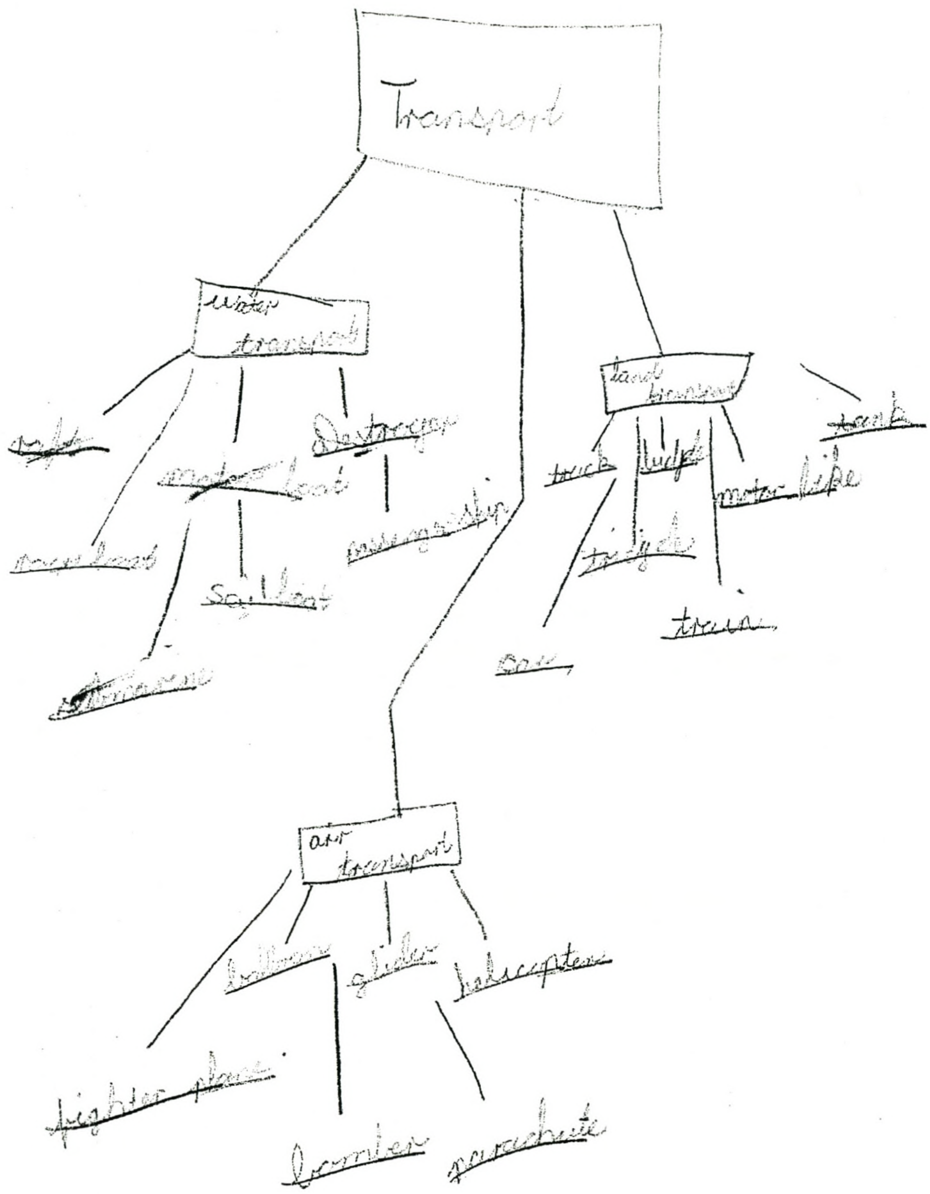
S 1/9


Long ee
3
See
bee
eel
lee
4
Seed
meet
beef
tree
beet
keep
Seem
beep
beer
5
Sheep
three
Creep
Strut
teeth
Sweet
6
beetle
asleep
indeed
Screen


Long ee
3
4
5
6
1 eel
2 lee
3 see
4 bee
5 wee
1 seem
2 seed
3 meet
4 seem
5 beer
1 creep
2 sheep
3 sleep
4 three
5 Greet
1 street
2 beetle
3 asleep
4 sweets
5 indeed


verkols
air
~~ballon~~
~~glider~~
around
car
trank
bicycle
car
sea
passingership
suit · bot
motor boat

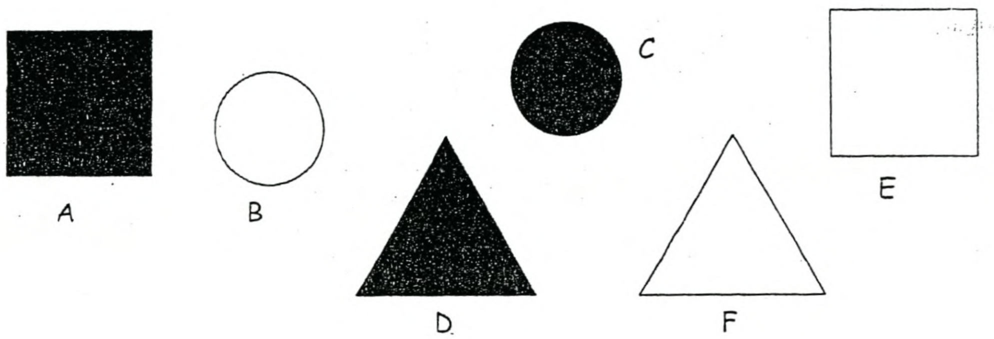

transport
land transport
tank
armored car
train long
air transport
bomber
passengers plane
sea transport
motor boat

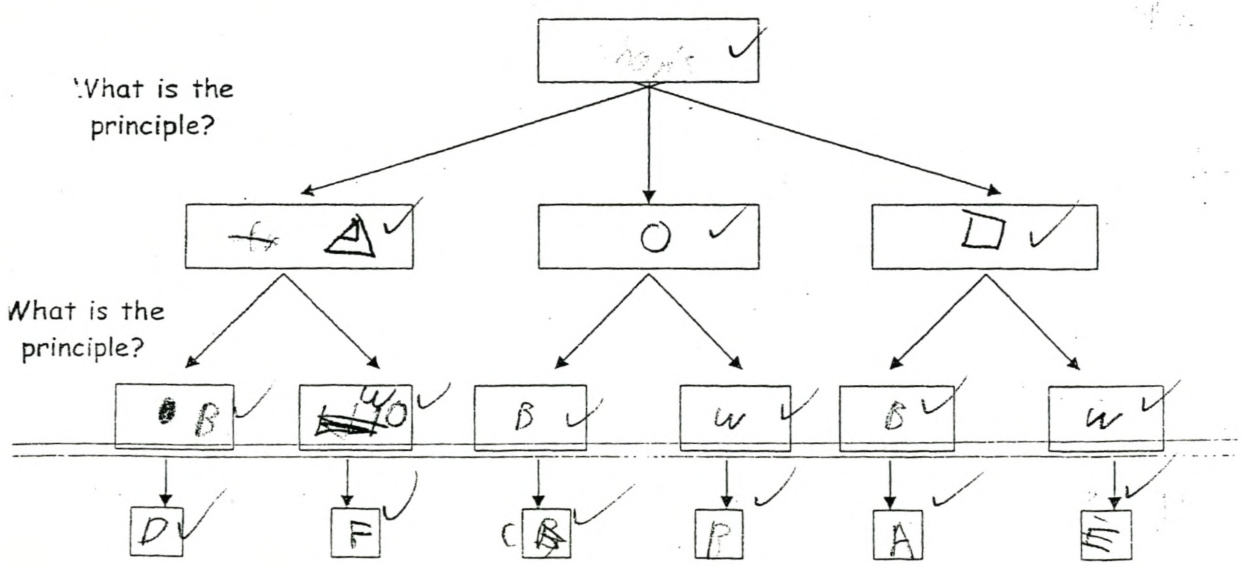

Transport
water transport
land transport
air transport
Destroyer
motor boat
sailboat
truck
motor bike
tank
tricycle
train
car
glider
helicopter
fighter plane
bomber
parachute

Name: ______

Please **Classify** these geometric shapes according to

Shape and **Color** using the Linear Diagram:





Name: ______

4. Hidden in this forest are the names of five sources of water. Can you find them?

Can you classify these sources of water into two groups: Natural & Manmade? Use the linear diagram for t

rain Bor Holes Rivers

water

springs

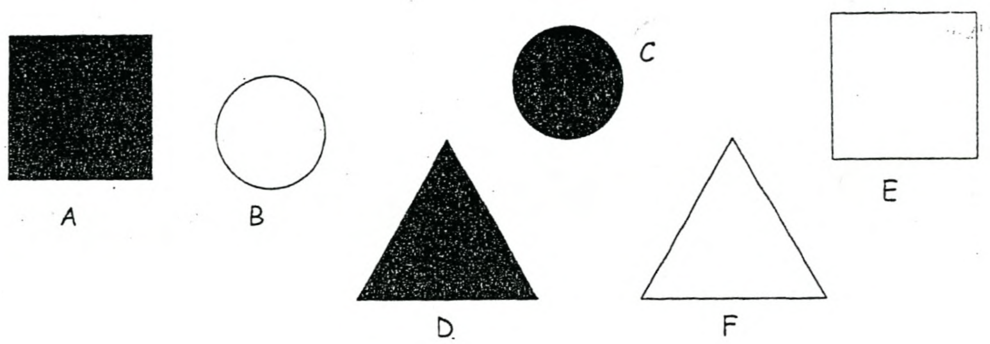
Borhole man natural rane

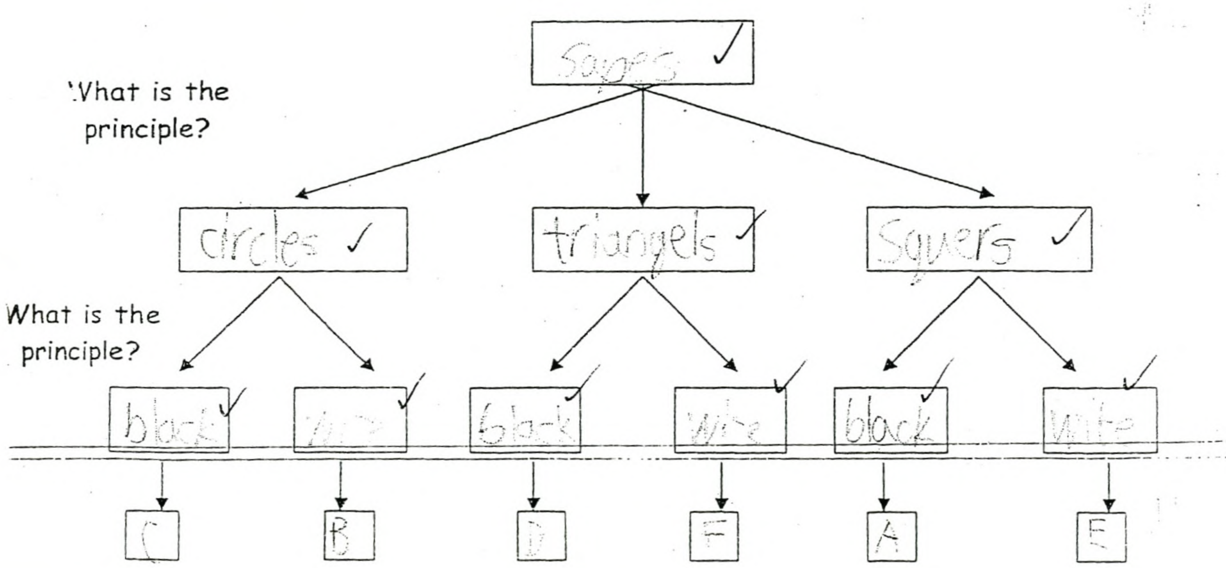
Dams

Name: ____________

Please **Classify** these geometric shapes according to

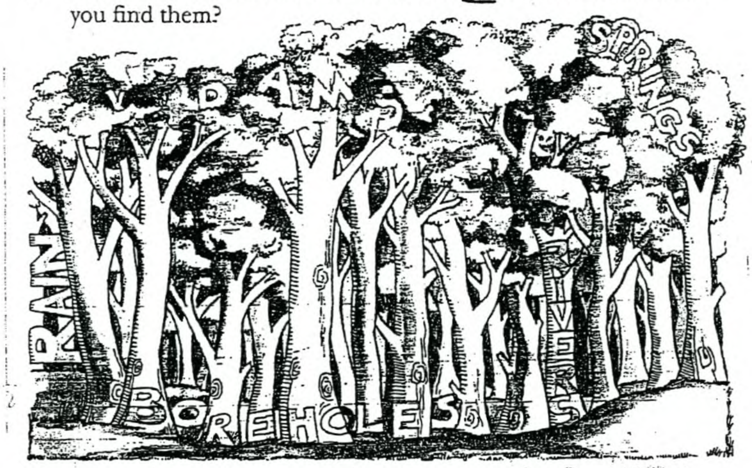
Shape and **Color** using the Linear Diagram:





Name: ______

4. Hidden in this forest are the names of five sources of water. Can you find them?



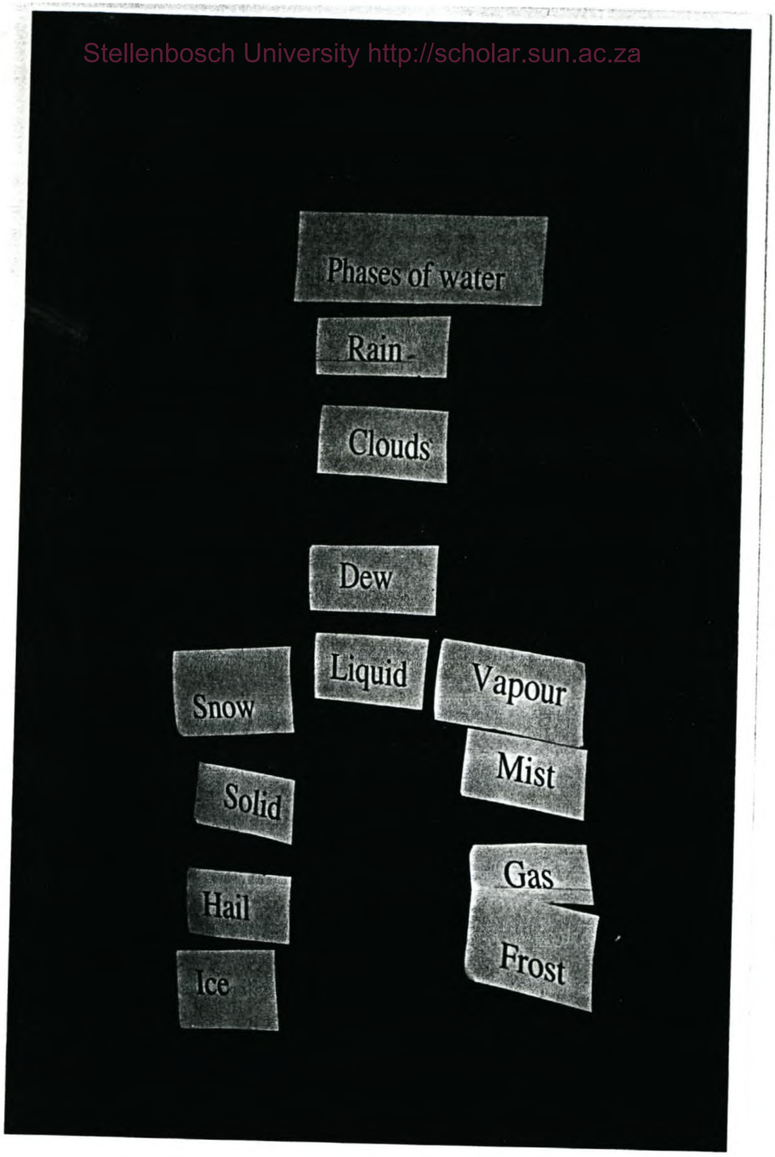
Rain Boreholes Rivers Springs Dams

Can you classify these sources of water into two groups: Natural & Manmade? Use the linear diagram for it

Water ✓

Springs ✓ Natural ✓ Manmade ✓

Rivers ✓ Rain ✓ Boreholes ✓ Dams ✓


Phases of water
Rain
Clouds
Dew
Snow
Liquid
Vapour
Mist
Solid
Gas
Hail
Frost
Ice


Liquid
Phases of water
Rain
Gas
Clouds
Solid
Mist
Ice
Hail